PB87-103099

Modified N.R.C. Version of the U.S.G.S. Solute Transport Model. Volume 1. Modifications

Oklahoma State Univ., Stillwater

Prepared for

Robert S. Kerr Environmental Research Lab.
Ada, OK

Sep 86

U.S. Department of Commerce
National Technical Information Service
NTIS

TECHNICAL REPORT DATA

(Please read Instructions on the reverse before completing)

1. REPORT NO.
EPA/600/2-86/089a

2.

3. RECIPIENT'S ACCESSION NO.
PB87-103099/AS

4. TITLE AND SUBTITLE
MODIFIED N.R.C. VERSION OF THE U.S.G.S. SOLUTE TRANSPORT MODEL, VOLUME 1: MODIFICATIONS

5. REPORT DATE
September 1986

6. PERFORMING ORGANIZATION CODE

7. AUTHOR(S)
Douglas C. Kent, L. LeMaster, and Jan Wagner

8. PERFORMING ORGANIZATION REPORT NO.

9. PERFORMING ORGANIZATION NAME AND ADDRESS
Oklahoma State University
Stillwater, Oklahoma 74078

10. PROGRAM ELEMENT NO.
CCUL1A

11. CONTRACT/GRANT NO.
CR-811142

12. SPONSORING AGENCY NAME AND ADDRESS
U.S. Environmental Protection Agency
Robert S. Kerr Environmental Research Laboratory
P.O. Box 1198
Ada, Oklahoma 74820

13. TYPE OF REPORT AND PERIOD COVERED

14. SPONSORING AGENCY CODE
EPA-600/15

15. SUPPLEMENTARY NOTES
Project Officer: Carl G. Enfield, FTS 743-2334

16. ABSTRACT

The methods described in this report can be used with the modified N.R.C. version of the U.S.G.S. Solute Transport Model to predict the concentration of chemical parameters in a contaminant plume. The two volume report contains program documentation and user's manual. The program documentation has been written for those who have a background in mathematics and/or computer systems while the user's manual was written in layman's terms for those who may not have a background in numerical methods or computer programming. The program should function properly on any computer that has a PL/I compiler available. The computer codes will be implemented on the Robert S. Kerr Environmental Research Laboratory (RSKERL), Ada, OK, computer and other EPA computer systems accessed by RSKERL.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group

18. DISTRIBUTION STATEMENT
Release to Public

19. SECURITY CLASS *(This Report)*
Unclassified

20. SECURITY CLASS *(This page)*
Unclassified

21. NO. OF PAGES
155

22. PRICE

EPA Form 2220-1 (Rev. 4-77) PREVIOUS EDITION IS OBSOLETE

PB87-103099

EPA/600/2-86/089a
September 1986

MODIFIED N.R.C. VERSION OF THE U.S.G.S. SOLUTE TRANSPORT MODEL,
VOLUME 1: MODIFICATIONS

by

Douglas C. Kent
School of Geology
Oklahoma State University
Stillwater, Oklahoma 74078

L. LeMaster
School of Geology
Oklahoma State University
Stillwater, Oklahoma 74078

J. Wagner
School of Chemical Engineering
Oklahoma State University
Stillwater, Oklahoma 74078

FINAL REPORT

U.S. Environmental Protection Agency

Cooperative Agreement No. CR811142-01-0

Project Officer

Carl G. Enfield

ROBERT S. KERR ENVIRONMENTAL RESEARCH LABORATORY
OFFICE OF RESEARCH AND DEVELOPMENT
U.S. ENVIRONMENTAL PROTECTION AGENCY
ADA, OK 74820

REPRODUCED BY
U.S. DEPARTMENT OF COMMERCE
NATIONAL TECHNICAL
INFORMATION SERVICE
SPRINGFIELD, VA. 22161

DISCLAIMER

The information in this document has been funded wholly or in part by the United States Environmental Protection Agency under assistance agreement number CR-811142 to Oklahoma State University. It has been subject to the Agency's peer and administrative review, and it has been approved for publication as an EPA document.

FOREWORD

The U.S. Environmental Protection Agency was established to coordinate administration of the major Federal programs designed to protect the quality of our environment.

An important part of the Agency's effort involves the search for information about environmental problems, management techniques and new technologies through which optimum use of the Nation's land and water resources can be assured and the threat pollution poses to the welfare of the American people can be minimized.

EPA's Office of Research and Development conducts this search through a nationwide network of research facilities.

As one of the facilities, the Robert S. Kerr Environmental Research Laboratory is the Agency's center of expertise for investigation of the soil and subsurface environment. Personnel at the laboratory are responsible for management of research programs to: (a) determine the fate, transport and transformation rates of pollutants in the soil, the unsaturated zone and the saturated zones of the suburface environment; (b) define the processes to be used in characterizing the soil and subsurface environment as a receptor of pollutants; (c) develop techniques for predicting the effect of pollutants on ground water, soil and indigenous organisms; and (d) define and demonstrate tha applicability and limitations of using natural processes, indigenous to the soil and subsurface environment, for the protection of this resource.

This report contributes to that knowledge which is essential in order for EPA to establish and enforce pollution control standards which are reasonable, cost effective and provide adequate environmental protection for the American public.

Clinton W. Hall

Clinton W. Hall
Director
Robert S. Kerr Environmental
Research Laboratory

PREFACE

The N.R.C. version of the U.S.G.S. Solute Transport Model (Tracy, 1982) has been modified in this study to incorporate options to (a) solve the ground-water flow equation using the Strongly Implicit Procedure, (b) simulate only the head distributions, (c) simulate a water-table aquifer, (d) input either transmissivity or hydraulic conductivity, and (e) output for use with SAS graphics programs. Stability, accuracy, and efficiency of the modified model are checked by applying the model to a number of test problems and comparing the results with those from the original model. In all cases, the modified model is found to be stable, efficient, and capable of producing reliable results. For most of these problems, the Strongly Implicit Procedure requires only about half the number of iterations than the Alternating-Direction Implicit Procedure to converge to a desired solution. Thus, using the SIP algorithm, it is possible to save a considerable amount of computer time and, therefore, computer cost.

The modifications lend themselves to a preprocessor program described in Volume 2 of this report (Kent, et al, 1986) which is an interactive program to be used in conjunction with this modified N.R.C. version of the U.S.G.S. Solute Transport Model. This preprocessor enables users to input data sets with a minimum degree of effort and confusion and provides maximum flexibility in managing the data.

The final report represents the completion of the contract with the Environmental Protection Agency entitled, "Mathematical Models for Transport and Transformation of Chemical Substances in Subsurface Environments", cooperative agreement number CR811142-01-0. The principal investigators are Dr. Douglas C. Kent and Dr. Jan Wagner. Ms. Lorraine LeMaster is the principal programmer. The cooperation and assistance of

Chi-Chung Chang, for his help in validating the modifications described in this report, and M. M. Hoque, for his work in the application of the SIP algorithm for this project, is gratefully acknowledged. Appreciation is also extended to the project officer, Carl G. Enfield, and to the entire staff of the Robert S. Kerr Environmental Research Center.

The methods described herein can be used to estimate or predict the concentrations in a contaminant plume. The value or accuracy of the prediction can be no better than the estimate of the hydrogeological and chemical parameters that are used in the simulation. Because these parameters can range within wide limits, so also can the prediction. Furthermore, the prediction must conform to fundamental hydrogeologic principles and common sense. The results of these predictive techniques must not be allowed to take precedence over sound field investigation, data collection, and interpretation at the study sites.

The information contained in this manual is believed to be correct at the time of publication. However, the authors assume no liability resulting from the use of the methods described in this publication.

CONTENTS

PAGE

PREFACE.......... i

1.0 INTRODUCTION.......... 1-1

- 1.1 Objectives.......... 1-2
- 1.2 History.......... 1-3
- 1.3 Applications.......... 1-4
- 1.4 Modifications.......... 1-4

2.0 TECHNICAL INFORMATION.......... 2-1

- 2.1 Introduction.......... 2-1
  - 2.1.1 Strongly Implicit Procedure.......... 2-1
  - 2.1.2 Transmissivity.......... 2-2
  - 2.1.3 Hydraulic Head Simulation.......... 2-3
  - 2.1.4 Mass Balance (Hydraulic).......... 2-3
  - 2.1.5 Saturated Thickness.......... 2-3
- 2.2 Solute Transport Flow of Control.......... 2-4
- 2.3 Specific Program Modifications.......... 2-4
  - 2.3.1 Named Common Blocks.......... 2-4
  - 2.3.2 Strongly Implicit Procedure(SIP).......... 2-7
  - 2.3.3 Transmissivity.......... 2-7
  - 2.3.4 Hydraulic Head Simulation.......... 2-8
  - 2.3.5 Mass Balance.......... 2-8
  - 2.3.6 Saturated Thickness.......... 2-9
  - 2.3.7 Additional Modifications.......... 2-9

3.0 MODEL PERFORMANCE.......... 3-1

- 3.1 Comparison of SIP and ADIP Iterative Techniques.......... 3-1
  - 3.1.1 Test Problem 1.......... 3-1
  - 3.1.2 Test Problem 2.......... 3-2
  - 3.1.3 Test Problem 3.......... 3-7
  - 3.1.4 Conclusions: SIP vs. ADIP.......... 3-9
- 3.2 Sensitivity to Grid Orientation.......... 3-12
- 3.3 Model Sensitivity to Particle Movement.......... 3-12
  - 3.3.1 Relation of Stability Criteria with Particle Movement.......... 3-13
  - 3.3.2 Methods for Particle Movement Sensitivity Analysis.......... 3-16
  - 3.3.3 Test Problem 1.......... 3-16
  - 3.3.4 Test Problem 2.......... 3-16
  - 3.3.5 Test Problem 3.......... 3-19
  - 3.3.6 Conclusions.......... 3-19

Preceding page blank

4.0 REFERENCES.. 4-1

APPENDICES

I Fortran IV Program Listing.................................. I-1
II Fortran IV Program Changes.................................. II-1
II-A Global Declarations and Named Common Blocks................ II-2
II-B Strongly Implicit Procedure................................ II-5
II-C Transmissivity.. II-7
II-D Hydraulic Head Simulation................................... II-9
II-E Mass Balance.. II-11
II-F Saturated Thickness... II-13
II-G Additional Modifications.................................... II-15
III Definition of Selected Fortran IV Program Variables........ III-1
IV Additional Data Requirements................................. IV-1
V Data Definitions and Input Formats............................ V-1
VI Units Summary Table.. VI-1
VII Input and Selected Output for Test Problem 2................ VII-1
VIII Input and Selected Output for Test Problem 3............... VIII-1

FIGURES

1 Simplified Flow Chart Illustrating the Major Steps in the Calculation Procedure....................................... 2-5
2 Simplified Flow Chart Illustrating the Major Steps in the Calculation of the Head Distributions.......................... 2-6
3 NODEID Matrix for Test Problem 1.............................. 3-3
4 NODEID Matrix for Test Problem 2.............................. 3-6
5 NODEID Matrix for Test Problem 3.............................. 3-10
6 Effect of CELDIS and NPTPND on CPU Time (Efficiency).......... 3-21

TABLES

1 Computational Efficiency for Steady-State Problems............ 3-4
2 Computational Efficiency for Transient Problem 1.............. 3-5
3 Computational Efficiency for Transient Problem 2.............. 3-8
4 Computational Efficiency for Transient Problem 3 3-11
5 Effect of CELDIS and NPTPND on Efficiency (CPU time) and Accuracy (Chemical Mass Balance Error) of Solution to Test Problem 1. 3-17
6 Effect of CELDIS and NPTPND on Efficiency (CPU time) and Accuracy (Chemical Mass Balance Error) of Solution to Test Problem 2.. 3-18
7 Effect of CELDIS and NPTPND on Efficiency (CPU time) and Accuracy (Chemical Mass Balance Error) of Solution to Test Problem 3.. 3-20

MODIFIED N.R.C. VERSION
OF THE U.S.G.S. SOLUTE TRANSPORT MODEL
VOLUME 1: MODIFICATIONS

1.0 INTRODUCTION

The purpose of this report is to describe modifications made to the N.R.C. version (Tracy, 1982) of the U.S.G.S. Solute Transport Model (Konikov and Bredehoeft, 1978).

The program modifications described in this manual are intended as a companion to the manual titled "Modified N.R.C. Version of the U.S.G.S. Solute Transport Model Volume 2: Interactive Preprocessor" (Kent, et al, 1986), prepared for the U.S. Environmental Protection Agency under a contract entitled "Mathematical Models for Subsurface Transport and Fate Predictions."

The project is providing a well documented set of transport and fate models ranging from relatively simple analytical models to complex numerical models. These models will be available on the EPA computer network in a format which would enable users to access the code, enter the required data, run the model, and receive the model results without extensive technical system support.

1.1 Objectives

The broad objective of this project is to develop and/or modify mathematical models in order to provide easier access to models which are capable of predicting the probable concentrations of chemical substances in ground-water systems resulting from the release of these substances onto the ground surface or into the subsurface.

More specifically, the objectives of this project report are to describe the modifications made to the N.R.C. version of the U.S.G.S.

Solute Transport Model. The modifications were made to improve its flexibility and increase its capabilities.

This report contains the following:

(1) Program Documentation and

(2) User's Manual

Documentation of the program is developed to include (a) the motivation for and limitations (assumptions) of the program modifications, (b) a description of the numerical methods used in the modifications, (c) listings of the source code or modifications, (d) one or more sets of test data, and (e) guidelines for further modifications which might be required to enable the use of the model on a variety of computer systems. A master copy of all source codes are prepared on magnetic tape in a format which is system independent. This type of program documentation has been written for those who have some background in mathematics and/or computer systems and languages. These documents are intended to serve as reference manuals for individuals who may be responsbile for maintaining, modifying, or transferring computer codes; as well as users who are also interested in the details of the computer codes.

The User's Manual includes (a) practical implications of assumptions and restrictions which are incorporated in the mathematical model, (b) the type of computer resources which may be required (for example computer memory, execution time, and input and output devices), (c) input data requirements and formats, and (d) detailed, step-by-step examples of practical problems. The user's manual is written in layman terms for those who may not have a background or experience in numerical methods or computer programming.

The modifications described in this report were developed and tested on an IBM 3081D computer. The modified model has also been tested on an IBM-PC microcomputer. With 20x20 matrices, 512K random access memory is necessary to execute the modified model. The modified model is a batch program, as are previous versions.

A "user-friendly" preprocessor has also been developed to simplify the creation of the data set necessary to run the modified version of the N.R.C. version of the U.S.G.S. Solute Transport Model. The preprocessor is interactive; that is, data is actively requested by the computer and entered by the modeler, while the preprocessor is running. The preprocessor is described in the companion volume entitled " Modified N.R.C. Version of the U.S.G.S. Solute Transport Model Volume 2: Interactive Preprocessor" (Kent, et al, 1986).

1.2 History

The ground-water flow equation is coupled with the solute-transport equation in the U.S.G.S. Solute Transport Model. The computer program uses an Alternating-Direction Implicit Procedure (ADIP) to solve a system of algebraic equations generated from a finite-difference approximation to the ground-water flow equation. The method of characteristics is used to solve the solute-transport equation. The method of characteristics uses a particle tracking procedure to represent convective transport and a two-step explicit procedure to solve a finite-difference equation that describes the effects of hydrodynamic dispersion, fluid sources and sinks and divergence of velocity.

Radioactive decay and equilibrium adsorption are incorporated for the U.S. Nuclear Regulatory Commission (Tracy, 1982). Procedures for radioactive decay, linear isotherm, Langmuir isotherm, and the Freundlich isotherm are added to the Solute Transport Model developed by Konikow and Bredehoeft (1978). The N.R.C. version of the Solute Transport Model is used in this project.

It is assumed that users will have some background in hydrogeology, soil science, or a similar field; and will have a basic understanding of the physical, chemical, and/or biological processes involved in a specific problem to be addressed. With this background, the report (Volumes 1 and 2) is intended to introduce the user to the model or model adaptation and areas of application and to provide tutorials on data requirements, model access and execution, and the management and interpretation of model output.

1.3 Applications

The modifications will enable various groups within federal and state regulatory agencies, as well as the private sector, to apply a more flexible version of the N.R.C. version of this model to the analysis of study sites such as those involving landfill or groundwater pollution related to conservative and non conservative elements (eg. brine pollution and hazardous elements). This model can also evaluate the effects of pumping and injection wells, recharge, constant head, nonhomogeneities in the aquifer, dispersive coefficients, and no flow boundiaries in the vicinity of the site.

1.4 Modifications

The U.S.G.S. Solute Transport Model was selected since it is well-documented and maintained. The modifications by Tracy (1982) which include adsorption and first-order reactions were incorporated. Additional modifications were made to the N.R.C. version of the U.S.G.S. Solute

Transport Model; the modifications include options for selecting (1) only the potentiometric head calculations or the potentiometric head and solute transport calculations, (2) water-table or confined-aquifer conditions, (3) adjustment of transmissivities after each time step to accommodate unconfined flow, (4) calculation of the initial saturated thickness from the bottom elevation and potentiometric head in an unconfined system, (5) incorporation of the SIP iterative technique which is an option for solving the fluid-flow equations, and (6) modification of model output for use with SAS graphics programs. Previous versions use the ADIP technique to solve the fluid-flow equations. Detailed descriptions of the modifications listed above can be found in the following chapter.

2.0 TECHNICAL INFORMATION

2.1 Introduction

The computer program of the N.R.C. version of the U.S.G.S. Solute Transport Model has been modified to incorporate the Strongly Implicit Procedure (SIP), introduce an option to run only the flow model, simulate either a confined or an unconfined aquifer, update the transmissivity for an unconfined aquifer, provide an option for the input of either transmissivity or hydraulic conductivity, provide an option for the input of either saturated thickness or bottom elevation in an unconfined system, and restructure the mass balance output for the flow model. The significance of these modifications will be discussed in the following sections. The implementations of the modifications are discussed in Section 2.3. Variables used for the modifications are defined in Appendix III. Additional information regarding previous implementations and modifications to the model may be found in documents by Konikow and Bredehoeft (1978) and Tracy (1982).

2.1.1 Strongly Implicit Procedure (SIP)

The N.R.C. version of the U.S.G.S. Solute Transport Model solves the ground-water flow equation, using the Alternating-Direction Implicit Procedure (ADIP) developed by Peaceman and Rachford (1955), to obtain head distributions. The seepage velocities are determined from the head distributions. These seepage velocities are used in solving the advective dispersive mass transport equation with adsorption and decay by the method of characteristics (MOC).

Some techniques have proven to be more capable and faster than ADIP in solving the flow equation for aquifers with irregular boundaries, nonhomogeneous properties, and water table-aquifers. One of these techniques, the Strongly Implicit Procedure (SIP), was developed by Stone (1968) and used by Trescott, et al (1976). The present report documents the development and implementation of the SIP algorithm as an alternative to the ADIP algorithm for solving the flow equation in the N.R.C. version of the U.S.G.S. Solute Transport Model. This algorithm is mathematically more complex and relatively difficult to program, but it facilitates the simulation of problems which cannot be efficiently solved by the ADIP algorithm. For details of the development of the SIP algorithm refer to Remson, et al (1971), Stone (1968), and Trescott, et al (1976).

A sensitivity analysis regarding the performance of the SIP and ADIP flow equations is discussed in Section 3.0.

2.1.2 Transmissivity

Transmissivity is a function of the saturated thickness and hydraulic conductivity of an aquifer. In an unconfined aquifer the saturated thickness changes along with the water table. These changes are caused by stresses such as pumpage, recharge, etc. It is necessary, therefore, to update the transmissivity with time. A modification has been made in the main program to perform this updating at the end of every time step of simulation. In the input section, a provision has been included to allow the input of either transmissivity or hydraulic conductivity data, according to necessity.

It should be noted that the hydraulic conductivity is considered uniform with regard to depth for this application. When dealing with a non-uniform situation, the model may be applied to a representative cross section of the study site. Examples of cross sectional applications may be found in the Master's Thesis by Chang (1985).

2.1.3 Hydraulic Head Simulation

It has been mentioned that the N.R.C. version of the U.S.G.S. Solute Transport Model has a flow portion and solute transport portion. Using the results of head distributions from the flow portion, the solute transport portion predicts the concentration distributions of contaminants. Sometimes, it may be desirable to apply the model to predict only the head distributions in an aquifer where there is no contamination problem or during early stages of calibration. In these situations, it is useful to use only the flow portion of the model to save the computer time and cost of running the solute transport part of the model.

2.1.4 Mass Balance (Hydraulic)

The format used in the mass balance for the flow portion of the model did not distinguish between recharge and injection. In the present modification, recharge and injection are printed separately in the output. Evapotranspiration has been dropped from the titles in the mass balance because there is no provision for estimating transient evapotranspiration from aquifers in the model. Leakage has been modified so that the direction of flow is indicated uniformly throughout the mass balance (negative for inflow, positive for outflow). These modifications clarify the components of the mass balance output.

2.1.5 Saturated Thickness

Saturated thickness is a function of the bottom elevation and potentiometric head in an unconfined aquifer. To aid the user in preparing data, a provision has been made to allow the input of either the bottom elevation or the saturated thickness for an unconfined aquifer. The initial input section has been modified to calculate the saturated thickness if the bottom elevation is input.

2.2 Solute Transport Flow of Control

The flow of operations in the modified N.R.C. version of the U.S.G.S. Solute Transport Model has been modified in the present study to provide options such as (a) head only simulation, (b) unconfined aquifer simulation, and (c) incorporation of the SIP algorithm to solve the flow equation. These additions are shown in the flow chart (Figures 1 and 2). Modifications made for this report are indicated by shaded boxes in Figures 1 and 2.

2.3 Specific Program Modifications

The FORTRAN source code for the modified N.R.C. version of the U.S.G.S. Solute Transport Model is reproduced in Appendix I. For reference purposes, columns 73-80 of each line contain a sequentially numbered label within each subroutine. Modifications to each subroutine are itemized by these label numbers in Appendix II and are described in the following sections.

2.3.1 Named Common Blocks

The following changes to the common blocks have been made in all the subroutines and in the main program. The integer variables FCON, IHEAD, and ISOLV have been added to the common block PRMI. The functions of these variables are described in Appendix IV. The two-dimensional array THICK has been added to the common block HEDA. This array is used to update the aquifer thickness after each time step when simulating unconfined conditions. The new thickness is then used to update the transmissivities and the related harmonic means. Another two-dimensional array HJ was added

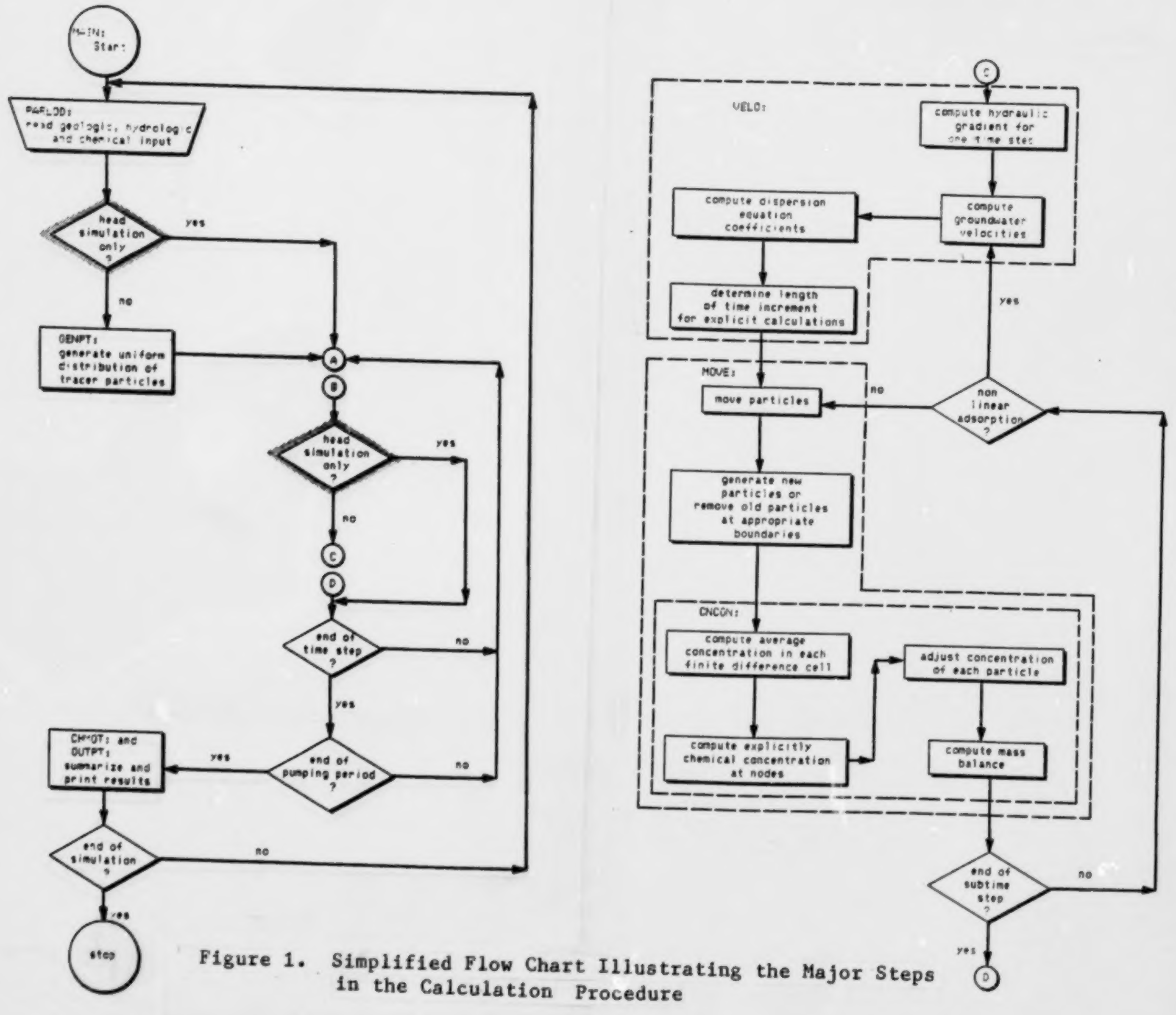
MAIN: Start
PARLOD: read geologic, hydrologic and chemical input
head simulation only ?
yes
no
GENPT: generate uniform distribution of tracer particles
A
B
head simulation only ?
yes
no
C
D
end of time step ?
no
yes
end of pumping period ?
no
yes
CHMOT: and OUTPT: summarize and print results
end of simulation ?
no
yes
stop
C
VELO:
compute hydraulic gradient for one time step
compute groundwater velocities
compute dispersion equation coefficients
determine length of time increment for explicit calculations
yes
MOVE:
move particles
no
non linear adsorption ?
generate new particles or remove old particles at appropriate boundaries
CNCON:
compute average concentration in each finite difference cell
adjust concentration of each particle
compute explicitly chemical concentration at nodes
compute mass balance
end of subtime step ?
no
yes
D

Figure 1. Simplified Flow Chart Illustrating the Major Steps in the Calculation Procedure

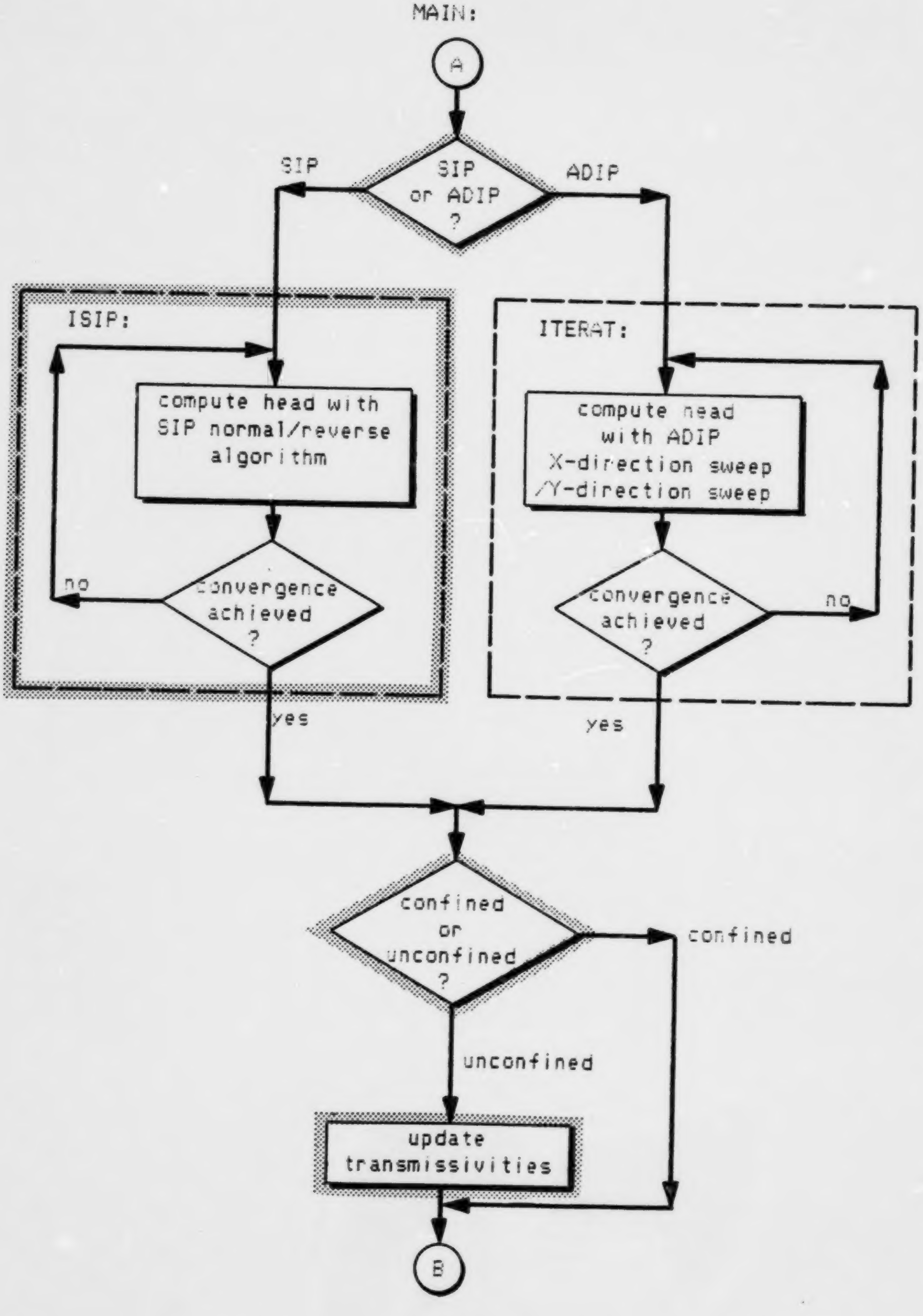
MAIN:
A
SIP
SIP or ADIP ?
ADIP
ISIP:
compute head with SIP normal/reverse algorithm
no
convergence achieved ?
yes
ITERAT:
compute head with ADIP X-direction sweep /Y-direction sweep
convergence achieved ?
no
yes
confined or unconfined ?
confined
unconfined
update transmissivities
B

Figure 2. Simplified Flow Chart Illustrating the Major Steps in the Calculation of the Head Distributions

to the common block HEDB. HJ is used as a temporary array for storing the predicted head distributions of the aquifer in the subroutine ISIP. HJ is a double precision variable and is declared as such in a REAL*8 declaration of each affected subroutine. In the common block BALM one real variable, TPQR, is added. This variable represents the total amount of recharge to the aquifer from distributed sources (injection excluded) during the simulation period. The modified lines are listed in Appendix II-A.

2.3.2 Strongly Implicit Procedure (SIP)

To implement the SIP algorithm in the N.R.C. version of the U.S.G.S. Solute Transport Model, a new subroutine, ISIP, has been added to the program. To incorporate ISIP into the program, some modifications were made to other subroutines. The flag used to incorporate this option is ISOLV. The routines affected are the Main program and the subroutine PARLOD. The changes to these routines are listed in Appendix II-B.

The acceleration parameter is set to unity in the implementation as recommended by Stone (1968). It is indicated in the article that the use of iteration parameters between 0.0 and 1.0 (as in this implementation) caused a relatively dense cluster of decay factors near unity. Therefore, no adjustment (acceleration parameter other than unity) is necessary. This may be altered, if desired, in the subroutines PARLOD (for input) and ISIP.

2.3.3 Transmissivity

To update the transmissivity for simulating an unconfined aquifer and to provide an option to input either transmissivity or hydraulic conductivity, the variables FCON and THICK are added as described in Section 2.3.1. The flag TP is added to PARLOD to determine which matrix is input. THICK is used for temporary storage of aquifer thickness during transmissivity updating in an unconfined aquifer. The routines that have been modified are the Main program and subroutines PARLOD and OUTPT. The lines modified are described in Appendix II-C.

2.3.4 Hydraulic Head Simulation

To include an option to simulate only the head distributions in an aquifer system, flag IHEAD is added to the common block PRMI. The modifications that have been made to the routines MAIN and PARLOD to simulate the head only distributions are listed in Appendix II-D.

2.3.5 Mass Balance

To add the mass balance modifications to the program, variable TPQR which represents the recharge to the aquifer, is included in the common block BALM. All modifications required to the subroutines PARLOD, ITERAT, and OUTPT are listed in Appendix II-E.

The mass balance calculations, performed in OUTPT, are as follows. Injection and pumping are totaled in lines H562-H568. Diffuse recharge and discharge are calculated in lines H572-H578. The leakage rates are calculated in lines H582-H640 and H745. The cumulative and rate net pumping are summed in lines H730 and H740. The mass balance residual and error are calculated between lines H757 and H805 as follows. The sources are the water released from storage minus the recharge, injection, and leakage into the aquifer. The sinks are the sum of the pumping and leakage out of the aquifer. The mass balance residual is the difference of the sources and sinks. The error is the residual times 100 and divided by one half of the total sum of the water through the system (sum of the sources and sinks).

2.3.6 Saturated Thickness

The option of entering either saturated thickness or bottom elevation for an unconfined aquifer is provided by adding the integer flag BTM to PARLOD. PARLOD is the only routine that has been modified. The changes are listed in Appendix II-F.

2.3.7 Additional Modifications

To facilitate the future use of model results with a graphics program, the changes noted in Appendix II-G were made to subroutines PARLOD, OUTPT, and CHMOT. The routine, GRPH, was added to write data to a data set that can be used with languages designed for graphical analysis such as SAS (1982). A description of procedures and graphic products are described in a companion volume entitled " Modified N.R.C. Version of the U.S.G.S. Solute Transport Model Volume 2: Interactive Preprocessor" (Kent, et al, 1986).

3.0 MODEL PERFORMANCE

3.1 Comparison of SIP and ADIP Iterative Techniques

To demonstrate and compare the performance of the modified model (SIP option) with the original model (ADIP option) several test problems were run. Two of the problems are taken from the original manual for the U.S.G.S. Solute Transport Model (Konikov and Bredehoeft, 1978), the third is taken from the manual for the N.R.C. version of the model (Tracy, 1982). A fourth test problem was run to demonstrate the applications of the model with both SIP and ADIP options to an unconfined aquifer system. The results for this problem are reported in the " Modified N.R.C. Version of the U.S.G.S. Solute Transport Model Volume 2: Interactive Preprocessor" (Kent, et al, 1986). An error criteria (TOL) of 0.01 was used in both SIP and ADIP runs for all test problems. Other values can be used to reflect the accuracy of the field data. Larger values for TOL (eg. 0.1) can be used to reduce the number of iterations which results in lower computer costs. All simulations were performed on an IBM 3081D computer.

3.1.1 Test Problem 1

This is the second problem from the manual for the original version of the U.S.G.S. Solute Transport Model (Konikov and Bredehoeft, 1978). This problem was designed to demonstrate the performance of the model on an aquifer where the flow field is strongly influenced by wells. The problem consists of one injection well and one pumping well. The effects of these wells are superimposed on a regional flow field which is controlled by two constant head boundaries. The injection well is a source of constant concentration of 100 parts per million. The initial concentration in the flow field is zero. This is a confined, homogeneous aquifer with a uniform thickness of 20 feet and hydraulic conductivity of 0.005 ft/sec. The potentiometric surface varies uniformly from 80 to 100 feet. This example was run for both steady state and transient flow simulations to demonstrate the performances of the SIP and ADIP options. A single time step was used in the steady state simulation for a pumping period of 2.5 years and in the case of the transient flow simulation, 10 equal time steps for this pumping period were used. To control the constant head boundaries, the NODEID matrix is used. For this problem the NODEID (ICODE) is designated as 2. Figure 3 shows the NODEID matrix. The CPU time required for each case, and the mass balance error resulting from each, are presented in Table 1 for steady state simulation and in Table 2 for transient simulation.

Table 1 indicates that the SIP algorithm requires fewer iterations, less CPU time, and is more accurate than the ADIP algorithm for steady state simulation of the site. Similar results are indicated in Table 2 for the transient flow simulation.

3.1.2 Test Problem 2

This is the third test problem from the manual for the original version of the U.S.G.S. Solute Transport Model (Konikow and Bredehoeft, 1978). This problem was selected to demonstrate the application of the model with the SIP and ADIP options in a flow field where a patch source of contamination exists and where the flow field is moderately influenced by wells. The problem consists of one withdrawal well located in a regional flow field (confined and homogeneous) that is controlled by two constant head boundaries. The constant contaminant sources are three central nodes (see Figure 4) along the upgradient constant head boundaries. All the parameters for this flow field are the same as Test Problem 1 (section 3.1.1) except the potentiometric head. The potentiometric head uniformly

0	0	0	0	0	0	0	0	0
0	2	2	2	2	2	2	2	0
0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0
0	2	2	2	2	2	2	2	0
0	0	0	0	0	0	0	0	0

Figure 3. - Nodeid Matrix For Test Problem 1

	NODEID CODES
ICODE#	1
ICODE	2
FCTR1	1.0
FCTR2	0
FCTR3	0
OVERRD	0

Table 1. - Computational Efficiency For Steady-State Problems

	Iterations and CPU Time				Mass Balance Error (%)			
	SIP		ADIP		SIP		ADIP	
Test Problem	No. of Iterations	Total CPU Time (sec)	No. of Iterations	Total CPU Time (sec)	Hydraulic Mass balance error	Chemical Mass balance error	Hydraulic Mass balance error	Chemical Mass balance error
1	7	1.45	13	1.48	1.53883E-02	-7.95201E+00	1.31100E-01	-6.86250E+00
2	6	1.43	13	1.48	8.80971E-03	-3.06842E+00	1.18518E-01	-3.05039E+00
3	2	4.03	1	3.95	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00

Table 2. - Computational Efficiency For Transient

Test Problem 1

	Iterations and CPU Time				Mass Balance Error (%)			
	SIP		ADIP		SIP		ADIP	
Time Step	No. of Itera-tions	Total CPU Time (sec)	No. of Itera-tions	Total CPU Time (sec)	Hydraulic Mass balance error	Chemical Mass balance error	Hydraulic Mass balance error	Chemical Mass balance error
1	7	1.90	13	2.02	2.16500E-02	-2.26953E+1	1.57759E-01	-2.26953E+01
2	3		6		3.22388E-02	-2.44461E+01	1.267004E-01	-2.44459E+01
3	2		3		2.50258E-02	-7.74837E+0	7.17186E-02	-1.92833E+01
4	1		3		1.96135E-02	-1.13217E+01	5.67972E-02	-1.31429E+01
5	1		2		1.53982E-02	-5.06631E+00	4.74312E-02	-6.48212E+00
6	1		1		1.26792E-02	-2.30856E+00	4.08725E-02	-4.43758E+00
7	1		1		1.07680E-02	-3.97417E+00	3.32994E-02	-5.89064E+00
8	1		1		9.35754E-03	-3.36166E+00	3.00519E-02	-6.00104E+00
9	1		1		8.27377E-03	-3.11102E+00	2.56867E-02	-5.72208E+00
10	1		1		7.42532E-03	-2.52546E+00	2.37322E-02	-4.11345E+00

0	0	0	0	0	0	0	0	0
0	2	2	1	1	1	2	2	0
0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0
0	2	2	2	2	2	2	2	0
0	0	0	0	0	0	0	0	0

Figure 4. - Nodeid Matrix For Test Problem 2

	NODEID CODES	
ICODE#	1	2
ICODE	2	1
FCTR1	1.0	1.0
FCTR2	0	100
FCTR3	0	0
OVERRD	0	0

varies from 75 to 100 feet. In this example, to control the constant head boundaries, 2 ICODEs are used for the NODEID matrix. ICODE 2 is used to represent the constant head boundaries except the three central nodes along the upgradient where the contaminant source patch exists. These three nodes are controlled with ICODE 1 (see Figure 4).

The results from the steady state simulation of this problem were reported in the U.S.G.S. Solute Transport manual (Konikov and Bredehoeft, 1978). In the present study this problem was run for both steady state and transient flow simulations using the same pumping period setup as Test Problem 1 (section 3.1.1). The CPU time required for and the mass balance error resulting from each option (SIP and ADIP) for both steady state and transient flow simulations are presented in Tables 1 and 3, respectively. Input data and the selected output for this test problem are presented in Appendix VII.

Table 1 indicates that the SIP algorithm requires fewer iterations, less CPU time, and is more accurate than the ADIP algorithm for steady state simulation of the site. Similar results are indicated in Table 3 for the transient flow simulation.

3.1.3 Test Problem 3

This problem is presented in the manual for the N.R.C. version of the U.S.G.S. Solute Transport Model (Tracy, 1982). In the present study this problem was selected to demonstrate the performance of the SIP and ADIP options in a solute transport problem where radioactive decay and sorption phenomena exist. This is considered a one-dimensional simulation. The flow field is influenced by one injection well and one withdrawal well and controlled by two constant head boundaries. The injection well is the

Table 3. - Computational Efficiency For Transient

Test Problem 2

	Iterations and CPU Time				Mass Balance Error (%)			
	SIP		ADIP		SIP		ADIP	
Time Step	No. of Itera-tions	Total CPU Time (sec)	No. of Itera-tions	Total CPU Time (sec)	Hydraulic Mass balance error	Chemical Mass balance error	Hydraulic Mass balance error	Chemical Mass balance error
1	6	1.90	13	2.01	8.58178E-03	-1.13870E+01	1.33714E-01	-1.13756E+01
2	3		6		2.59461E-02	6.32174E+00	1.10818E-01	6.3452E+00
3	2		3		2.03862E-02	-7.09691E-01	6.32410E-01	-6.97257E-01
4	1		3		1.61486E-02	-3.16578E+00	5.03580E-02	-3.15459E+00
5	1		2		1.27278E-02	1.74106E+00	4.21897E-02	-1.75011E+00
6	1		1		1.04736E-02	-2.05990E+00	3.64501E-02	-2.06982E+00
7	1		1		8.89435E-03	-8.19606E+00	2.97079E-02	-8.24349E+00
8	1		1		7.71704E-03	-1.11926E+00	2.68048E-02	-1.12535E+00
9	1		1		6.81105E-03	-1.47943E+00	2.39371E-02	-1.48265E+00
10	1		1		6.12330E-03	-1.56466E+00	2.12051E-02	-1.56501E+00

contaminant source in this flow field and has a concentration of 500 parts per million. In the NODEID matrix, the constant head boundaries are controlled by ICODE 2 (see Figure 5). This flow field is also considered to be a confined, homogeneous aquifer. Simulations were made for both steady state and transient flow. The CPU time required to run these test problems and the resulting mass balance error are presented in Table 1 for steady state and in Table 4 for transient flow simulations. Input data and the selected output for time steps 1 and 10 are presented in Appendix VIII.

Table 1 indicates that the ADIP algorithm requires less time and fewer iterations than the SIP algorithm for this one-dimensional, steady state simulation. Results of the transient flow simulation, in Table 4, also indicate the ADIP algorithm is slightly more efficient than the SIP algorithm. There are no significant differences in the accuracy of the algorithms for either transient flow or steady state simulations.

3.1.4 Conclusions: SIP vs. ADIP

For Test Problems 1 and 2, which are relatively complex in nature, the SIP algorithm requires (for steady state simulation) only about half of the number of iterations as the ADIP algorithm to converge to the desired solution. For a less complex problem, such as Test Problem 3 (one-dimensional), the SIP algorithm provides a rate of convergence similar to that of the ADIP algorithm. In the case of transient flow simulation, the SIP algorithm provides a signicantly faster convergence rate (fewer iterations) than the ADIP algorithm for the first few time steps of Test Problems 1 and 2. However, as the simulation proceeds, the number of iterations required by each algorithm, and the difference between the number of iterations for each algorithm, becomes insignificant. The results are shown in Tables 1, 2, 3, and 4. These results indicate that

0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Figure 5. - Nodeid Matrix For Test Problem 3

	NODEID CODES
ICODE#	1
ICODE	2
FCTR1	0.3
FCTR2	0
FCTR3	0
OVERRD	0

Table 4. - Computational Efficiency For Transient

Test Problem 3

	Iterations and CPU Time				Mass Balance Error (%)			
	SIP		ADIP		SIP		ADIP	
Time Step	No. of Itera-tions	Total CPU Time (sec)	No. of Itera-tions	Total CPU Time (sec)	Hydraluic Mass balance error	Chemical Mass balance error	Hydraulic Mass balance error	Chemical Mass balance error
1	2	4.095	1	4.025	0.00000E+00	3.78286E+00	0.00000E+00	3.78286E+00
2	1		1		0.00000E+00	-1.53608E+01	0.00000E+00	-1.53608E+01
3	1		1		0.00000E+00	-6.28198E+00	0.00000E+00	-5.58985E+00
4	1		1		0.00000E+00	-6.28198E+00	0.00000E+00	-6.28198E+00
5	1		1		0.00000E+00	-1.03799E+00	0.00000E+00	-6.28198E+00
6	1		1		-9.55977E-06	-7.16792E+00	-9.55977E-06	-7.16792E+00
7	1		1		-7.16972E-06	-2.42799E+00	-7.16972E-06	-7.16792E+00
8	1		1		0.00000E+00	-6.90429E+00	0.00000E+00	-6.90429E+00
9	1		1		0.00000E+00	-2.82789E+00	0.00000E+00	-6.90429E+00
10	1		1		0.00000E+00	-2.03537E+00	0.00000E+00	-2.03537E+00

SIP is, overall, a more powerful iterative algorithm than ADIP. Because SIP generally requires fewer iterations for a given simulation than ADIP, computer time and cost should be less when the SIP technique is used.

3.2 Sensitivity to Grid Orientation

A word should be said with regard to the relationship of the SIP and ADIP iterative techniques to the physical setup of the data for a simulation. This setup is in regard to the gradient and the X-Y grid system. The two setups are with the flow along the columns (X axis) and the flow along the rows (Y axis). For an isotropic, homogeneous site with uniform gradient, no significant differences (differences of less than or equal to 1%) were found between the results of either iterative technique or flow setup. With an anisptropic site, however, significant differences, related to the direction of flow, were found. The anisotropic characteristics were accurately represented in the results when the flow was along the columns. However, when the flow was simulated along the rows, the anisotropy was apparently ignored. Those results matched the isotropic simulations. No apparent explanation was found for this in the program code and further analysis is beyond the scope of this study.

3.3 Model Sensitivity to Particle Movement

The previous sections discussed the performance of the Solute Transport Model in relation to different iterative techniques used to determine potentiometric head. This section presents the results of a sensitivity analysis of the parameters affecting particle movement.

The maximum cell distance per particle move (CELDIS) and the initial number of particles per node (NPTPND) are the two execution parameters that must be specified by the users to simulate the transport of solute in an aquifer system with the modified N.R.C. version of the U.S.G.S. Solute Transport Model. These two parameters influence the accuracy, precision, and efficiency (computational time and cost) of the solution to a particular problem.

Konikow and Bredehoeft (1978) performed sensitivity analyses on a Honeywell 60/68 computer using the ADIP algorithm to solve the flow equation. For this study, the SIP algorithm is used to solve the flow equation for all the test problems and the program is executed on an IBM 3081D computer. The results of this analysis may be useful to users in the developmental stages of simulations especially in relation to CELDIS and NPTPND.

Before discussing the sensitivity of particle movement, it is important to discuss briefly how the stability criteria controls the size and number of subtime steps (automatically generated in the program and used in the solute transport equation) and how the subtime steps may vary according to the value of CELDIS.

3.3.1 Relation of Stability Criteria with Particle Movement

For an explicit finite difference solution of dispersion terms of the solute transport equation, stability checks may be given as:

$$\Delta t <= \underset{\text{(over grid)}}{\text{Min}} \left[\frac{0.5}{D_{xx} / (\Delta X)^2 + D_{yy} / (\Delta Y)^2} \right] \quad ......(1)$$

where

Δt = time increment (T),

D_{xx} = dispersion coefficient in the X direction (L^2/T),

D_{yy} = dispersion coefficient in the Y direction (L^2/T),

ΔX = grid size in the X direction, XDEL, (L),

and ΔY = grid size in the Y direction, YDEL, (L).

This equation gives the maximum permissible time increment which is the minimum of all the time steps (Δt) computed for each individual node in the entire grid.

The second stability criteria relates the effects of mixing groundwater of one concentration with injected or recharged water of different concentration represented by the source terms. This relationship is given as:

$$\Delta t <= \min_{\text{(over grid)}} \left[\frac{\epsilon b}{W} \right] \qquad \text{..........(2)}$$

where

ϵ = effective porosity, POROS, (dimensionless),

b = thickness of the aquifer, THCK, (L),

and W = volume flux per unit area (L/T).

A third type of stability check involves the movement of points computed for convective transport terms of the solute transport equation. This relationship is developed as follows:

$$dx = \Delta t \, V_x \qquad \text{..............................(3a)}$$

$$dy = \Delta t \, V_y \qquad \text{..............................(3b)}$$

where

dx = distance traveled in the X direction (L),

dy = distance traveled in the Y direction (L),

V_x = maximum velocity in the X direction, VMAX, (L/T),

and V_y = maximum velocity in the Y direction, VMAY, (L/T).

If dx is greater than ΔX or dy is greater than ΔY, it might be possible for particles to move beyond the boundaries of the grid during one time increment. Thus, for a given velocity field and grid, some restrictions must be placed on the size of the time increment to assure that neither dx nor dy exceed some critical distances (dx^* and dy^*). These critical distances relate the dimension of the grid by:

$$dx^* = \gamma \Delta X \text{ ....(4a)}$$

$$dy^* = \gamma \Delta Y \text{ ....(4b)}$$

where

γ = is the fraction of the grid dimensions that a particle will be allowed to move, CELDIS, ($0 <= \gamma <= 1$).

From equations 3 and 4 stability relationships may be obtained as:

$$\Delta t <= \frac{\gamma \Delta X}{V_x} \text{ ....(5a)}$$

$$\Delta t <= \frac{\gamma \Delta Y}{V_y} \text{ ....(5b)}$$

If the time steps used to solve the flow equation exceeds the smallest of the time steps calculated by equations 1, 2, and 5, then the time step will be subdivided into the appropriate number of smaller time increments which will be used to solve the solute transport equation. Therefore, in every time step (used to solve flow equation) each particle moves a maximum distance which is equal to the number of subtime steps times γ (represented as CELDIS in the model).

In equation 5, the optimum size of the time step is dependent on the value of γ (ΔX, ΔY, V_x, and V_y are the parameters of the flow equation). If CELDIS is smaller, the total number of time steps needed to solve the solute transport equation increases and hence the efficiency of the model decreases. This relationship can be observed from the results in athe following sections.

3.3.2 Methods for Particle Movement Sensitivity Analysis

The sensitivity of the model to the number of (density) tracer particles may be evaluated by varying the value of NPTPND and keeping CELDIS constant. From the study by Konikow and Bredehoeft (1978), it was determined that the accuracy (chemical mass balance error) of the solution is directly proportional to the density (number of particles per node), while the efficiency is inversely proportional to the density.

The influence of the maximum cell distance per particle move may be evaluated by keeping NPTPND constant and running the model with several possible values of CELDIS. Konikow and Bredehoeft (1978) reported that the relationship between CELDIS and chemical mass balance error is not as simple and straightforward as for NPTPND. The effect of CELDIS on the chemical mass balance error seems to be completely problem dependent. To demonstrate the effects of CELDIS and NPTPND for different problems, the sensitivity of the modified model to these parameters has been analyzed for Test Problems 1, 2, and 3. The results of the sensitivity analysis are presented in the following sections.

3.3.3 Test Problem 1

Table 5 shows trends for Test Problem 1 and indicates that the efficiency increases with the increase of CELDIS. On the other hand the efficiency decreases with the increase of NPTPND. With respect to accuracy, the table shows no regular trend relating to either the CELDIS or the NPTPND.

3.3.4 Test Problem 2

For Test Problem 2, the trends of efficiency and accuracy are similar (see Table 6) to that of Test Problem 1 (Table 5). However, for Test

TABLE 5. Effect of CELDIS and NPTPND on Efficiency (CPU time) and Accuracy (Chemical Mass Balance Error) of Solution to Test Problem 1.

NPTPND	4		5		8		9	
CELDIS	CPU	Chemical Mass Balance Error %	CPU	Chemical Mass Balance Error %	CPU	Chemical Mass Balance Error %	CPU	Chemical Mass Balance Error %
0.25	1.63	-4.10944E-01	1.97	-9.46637E-01	2.15	-2.02629E-00	2.47	-2.63050E-00
0.5	0.95	-3.83740E-00	1.05	-2.06772E-00	1.19	7.93923E-00	1.42	-2.85956E-00
0.75	0.88	-4.42353E-00	1.0	3.38968E-00	1.11	1.16942E+01	1.28	1.47898E-01
1.0	0.87	-4.42353E-00	1.0	3.38968E-00	1.13	1.16942E+01	1.28	1.47898E-01

TABLE 6. Effect of CELDIS and NPTPND on Efficiency (CPU time) and Accuracy (Chemical Mass Balance Error) of Solution to Test Problem 2.

NPTPND	4		5		8		9	
CELDIS	CPU	Chemical Mass Balance Error %	CPU	Chemical Mass Balance Error %	CPU	Chemical Mass Balance Error %	CPU	Chemical Mass Balance Error %
0.25	1.82	-3.07111E-00	2.00	-3.96768E-00	2.24	-4.58213E-00	2.46	-3.94209E-00
0.5	1.09	-1.79805E-00	1.18	-2.70483E-00	1.40	-2.45453E-00	1.41	-3.06842E-00
0.75	0.78	-2.87525E-01	0.85	4.70031E-01	0.93	-8.00412E-02	0.99	-2.08099E-01
1.0	0.68	9.28112E-01	0.73	-1.22564E-00	0.80	-2.83650E-00	0.84	-7.57554E-00

Problem 1, efficiency increases more rapidly with the increase of CELDIS than does Test Problem 2. The major difference between Test Problems 1 and 2 is the introduction of the contaminant source. In Test Problem 1, an injection source is used, and in Test Problem 2 a patch source of contamination is used. The injection source of contamination may be responsible for the relatively greater increase in efficiency.

3.3.5 Test Problem 3

For Test Problem 3, it is found (see Table 7) that the efficiency of the model does not vary significantly with the CELDIS, but it does with the NPTPND. Similarly, the accuracy varies with the NPTPND more than that of with the CELDIS. No trend could be found with regard to the variation in accuracy.

3.3.6 Conclusions

A comparison between the variation of efficiency for Test Problems 2 and 3 are shown in Figure 6. The variation of efficiency for Test Problem 1 is not shown in Figure 6 because it has a trend similar to Test Problem 1. Test Problem 3 is a one-dimensional problem and a radioactive decay term is considered in this problem. These two factors may be responsible for the differences observed (see Figure 6) between the results of Test Problems 2 and 3.

It is clear from the results of the analysis that the effects of CELDIS and NPTPND differ from problem to problem. However, the effects of CELDIS and NPTPND on the efficiency of the model follow a regular trend, though the effects of these two parameters on the accuracy of the results does not have any regular relationship.

TABLE 7. Effect of CELDIS and NPTPND on Efficiency (CPU time) and Accuracy (Chemical Mass Balance Error) of Solution to Test Problem 3.

NPTPND	4		5		8		9	
CELDIS	CPU	Chemical Mass Balance Error %	CPU	Chemical Mass Balance Error %	CPU	Chemical Mass Balance Error %	CPU	Chemical Mass Balance Error %
0.25	2.87	-2.78318E-00	2.89	3.08818E-00	3.58	-2.65033E-00	3.94	-2.17975E-00
0.5	2.88	-2.78318E-00	2.90	-3.08818E-00	3.57	-2.65033E-00	3.94	-2.17975E-00
0.75	2.86	-2.78318E-00	3.22	-3.08818E-00	3.57	-2.65033E-00	3.94	-2.17975E-00
1.00	2.86	-2.78318E-00	3.21	-3.08818E-00	3.56	-2.65033E-00	3.93	-2.17975E-00

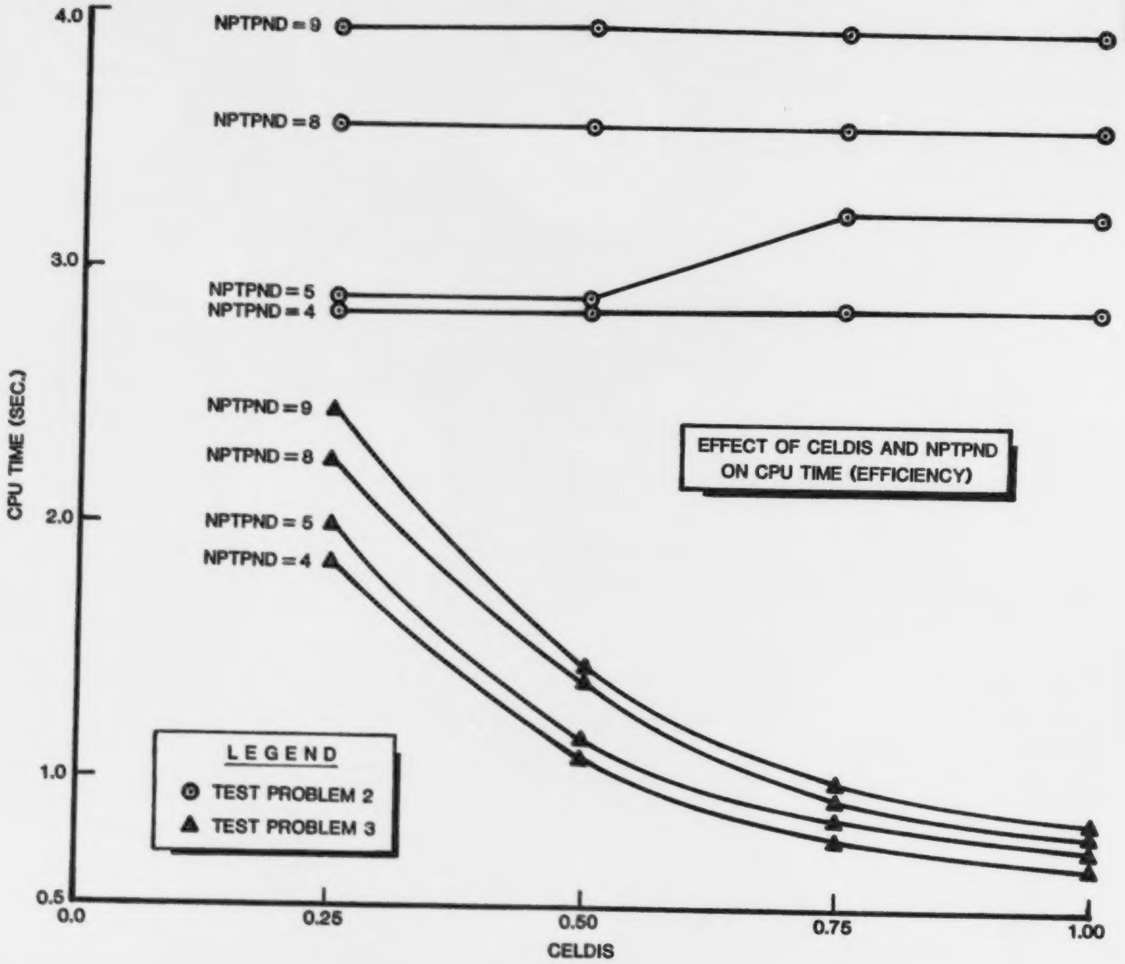

Figure 6. Effect of CELDIS and NPTPND on CPU Time (Efficiency)

Model users are assumed to be able to relate their problem to the problems used in this analysis and choose the approximate values of CELDIS and NPTPND that would result in an efficient and accurate solution. If a problem is not comparable to any one of the test problems, the modeler may want to perform a sensitivity analysis in an attempt to determine the appropriate values of CELDIS and NPTPND for the problem being considered. However, because of the possible trade off between accuracy and efficiency it recommended that the modeler start with NPTPND as 4 or 5 and CELDIS as 0.75 to 1.0 for maximum efficiency (see Figure 6).

4.0 REFERENCES

Chang, C., 1985, "Hydrogeologic Approach to the Characterization of Aquifer Contamination and Restoration Using Mathematical Models", Master's Thesis, Oklahoma State University, Stillwater, Oklahoma.

Kent, D. C., L. LeMaster and J. Wagner, 1986, "Modified N.R.C. Version of the U.S.G.S. Solute Transport Model Volume 2: Interactive Preprocessor", U.S. Environmental Protection Agency, CR-811142-01-0.

Kent, D. C., W. A. Pettyjohn and T. A. Prickett, 1985, "Analytical Methods for the Prediction of Leachate Plume Migration", Ground Water Monitoring Review, v. 5, no. 2,pp. 46-59.

Kent, D. C. and J. Wagner, 1983, "Mathematical Models for Transport and Transformation of Chemical Substances in Subsurface Environments", Annual Report, National Center for Ground Water Research.

Konikow, L. F. and J. D. Bredehoeft, 1978, "Computer Model for Two-Dimensional Solute Transport and Dispersion in Groundwater", Technique of Water Resources Investigation of the U.S. Geological Survey, Book 7, Ch. 2, 90pp.

Peaceman, D. W. and H. H. Rachford, 1953, "The Numerical Solution of Parabolic and Elliptic Partial Differential Equations", SIAM Jour. 3, pp. 28-41.

Remson, I., G. M. Hornberger and F. J. Molz, 1971, "Numerical Methods in Subsurface Hydrology", Wiley Interscience, New York, 389pp.

SAS Institute Inc., 1982, "SAS User's Guide, 1981 Edition", Cary, N.C.: SAS Institute Inc., 126 pp.

Stone, H. L., 1968, "Iterative Solutions of Implicit Approximations of Multidimensional Partial Differential Equations", SIAM Jour., Numerical Analysis 5, pp 530-558.

Tracy, J.V., 1983, "Users Manual and Documentation of Adsorption and Decay Modifications to the U.S.G.S. Solute Transport Model", US Nuclear Regulatory Commission, NUREG/Cr-2502.

Trescott, P. C., G. F. Pinder and S. P. Larson, 1976, "Finite-Difference Model for Aquifer Simulation in Two Dimensions with Results of Numerical Experiments", Techniques of Water Resources Investigations of the U.S. Geological Survey, Book 7, Ch. C1, 116 pp.

APPENDIX I

FORTRAN IV PROGRAM LISTING

```
**** TSO FOREGROUND HARDCOPY ****
DSNAME=U11236C.KONIMOD.CNTL
                                                              (MAIN     )
C USE META COMMANDS (BELOW) WHEN COMPILED ON MICROCOMPUTER
C $NOFLOATCALLS
C $STORAGE:2
C    DISTRIBUTED BY LOW-LEVEL WASTE LICENSING BRANCH, NRC
C    LOGICAL UNIT "5" IS INPUT
C    LOGICAL UNIT "6" IS OUTPUT
C    LOCICAL UNIT "7" IS OPTIONAL
C    ************************************************************        A   10
C    *                                                          *        A   20
C    *     SOLUTE TRANSPORT AND DISPERSION IN A POROUS MEDIUM   *        A   30
C    *      NUMERICAL SOLUTION --- METHOD OF CHARACTERISTICS    *        A   40
C    *      PROGRAMMED BY J. D. BREDEHOEFT AND L. F. KONIKOW    *        A   50
C    *               REVISED APRIL 1979, MARCH 1980             *        A   55
C    *               REVISED DECEMBER 1980                      *        A   56
C    *               REVISED AUGUST 1981                        *        A   57
C    *               REVISED OCTOBER 1983                       *        A   58
C    *     RADIONUCIDE DECAY AND NONLINEAR SORBTION MODIFICATIONS *      USNRC
C    *      DEVELOPED AND IMPLEMENTED FOR US NRC BY J. TRACY    *        USNRC
C    *                AUGUST-SEPTEMBER 1981                     *        USNRC
C    *               MODIFIED NRC VERSION                       *        OSU
C    *        OF THE USGS SOLUTE TRANSPORT MODEL,               *        OSU
C    *              VOLUME 1:  MODIFICATIONS                    *        OSU
C    *                        BY                                *        OSU
C    *       D.C. KENT, L. LEMASTER, AND J. WAGNER              *        OSU
C    *                       FOR                                *        OSU
C    *       U.S. ENVIRONMENTAL PROTECTION AGENCY               *        OSU
C    *                  JANUARY, 1986                           *        OSU
C    ************************************************************        A   60
     CHARACTER*8 TITLE                                                   A   70
     REAL*8 TMRX,VPRM,HI,HR,HC,HK,WT,REC,RECH,TIM,AOPT                   A   71
     REAL*8 XDEL,YDEL,S,AREA,SUMT,RHO,PARAM,TEST,TOL,PINT,HMIN,PYR       A   90
     REAL*8 TINT,ALPHA1,ANITP                                            A  100
     REAL*8 TMSUM,ANTIM,TDEL                                             A  110
     REAL*8 HJ                                                           A  116
     INTEGER FCON                                                        A  117
     COMMON /PRMI/ NTIM,NPMP,NPNT,NITP,N,NX,NY,NP,NREC,INT,NNX,NNY,NUMO  A  118
    1BS,NMOV,IMOV,NPMAX,ITMAX,NZCRIT,IPRNT,NPTPND,NPNTMV,NPNTVL,NPNTD,N  A  120
    2PNCHV,NPDELC,ICHK,FCON,IHEAD,ISOLV                                  A  130
     COMMON /PRMC/ NODEID(20,20),NPCELL(20,20),NPOLD(20,20),LIMBO(500),  A  142
    1IXOBS(5),IYOBS(5)                                                   A  145
    2,NDECAY,NSORB                                                       A  146
     COMMON /HEDA/ THCK(20,20),PERM(20,20),TMWL(5,50),TMOBS(50),ANFCTR   USNRC
    1,THICK(20,20)                                                       A  170
     COMMON /HEDB/ TMRX(20,20,2),VPRM(20,20),HI(20,20),HR(20,20),HC(20,  A  171
    120),HK(20,20),WT(20,20),REC(20,20),RECH(20,20),TIM(100),AOPT(20),T  A  180
    2ITLE(10),XDEL,YDEL,S,AREA,SUMT,RHO,PARAM,TEST,TOL,PINT,HMIN,PYR     A  190
    3,HJ(20,20)                                                          A  200
     COMMON /CHMA/ PART(3,3200),CONC(20,20),TMCN(5,50),VX(20,20),VY(20,  A  205
    120),CONINT(20,20),CNRECH(20,20),POROS,SUMTCH,BETA,TIMV,STORM,STORM  A  210
    2I,CMSIN,CMSOUT,FLMIN,FLMOT,SUMIO,CELDIS,DLTRAT,CSTORM               A  220
    3,DCYLAM,BLKDEN,SRBRAT,SRBSAT,SRBALF,VOLDCY,VOLSRB,SRBDCY            A  230
C    ***********************************************************         USNRC
C     ---LOAD DATA---                                                    A  240
     INT=0                                                               A  250
     TMSUM = 0.0                                                         A  260
     N = 0                                                               A  265
     CALL PARLOD                                                         A  266
     IF (IHEAD .EQ. 0) CALL GENPT                                        A  270
C    ***********************************************************         A  281
C    ---START COMPUTATIONS---                                            A  290
C       ---COMPUTE ONE PUMPING PERIOD---                                 A  300
                                                                         A  310
```

```
      DO 150 INT=1,NPMP
      N = 0
      IF (INT.GT.1) TMSUM = TMSUM + PYR
      IF (INT.GT.1) CALL PARLOD
      IPCK=0
C        ---COMPUTE ONE TIME STEP---
      DO 130 N=1,NTIM
      IPRNT=0
C        ---LOAD NEW DELTA T---
      TINT=SUMT-TMSUM
      TDEL=DMIN1(TIM(N),PYR-TINT)
      SUMT=SUMT+TDEL
      IF (TDEL.EQ.(PYR-TINT)) IPCK=1
      TIM(N)=TDEL
      REMN=MOD(N,NPNT)
C     **********************************************************
C     IF (S.EQ.0.0.AND.ICHK.EQ.0.AND.(N.GT.1.OR.INT.GT.1)) GO TO 101
      IF (ISOLV.EQ.0) GO TO 117
      CALL ISIP
      GO TO 125
  117 CONTINUE
      CALL ITERAT
C     ---UPDATE THCK,TMRX---
  125 IF (FCON.EQ.0) GO TO 119
      DO 111 IY=1,NY
      DO 111 IX=1,NX
      IF (THICK(IX,IY).EQ.0.0) GO TO 111
      THCK(IX,IY) = THICK(IX,IY) - HI(IX,IY) + HK(IX,IY)
  111 CONTINUE
      NNX = NX - 1
      NNY = NY - 1
      DO 115 IY=2,NNY
      DO 115 IX=2,NNX
      IF (PERM(IX,IY).EQ.0.0) GO TO 115
      TMRX(IX,IY,1)=2.*PERM(IX,IY)*THCK(IX,IY)*PERM(IX+1,IY)*THCK(IX+1,I
     1Y)/(PERM(IX,IY)*THCK(IX,IY)*XDEL+PERM(IX+1,IY)*THCK(IX+1,IY)*XDEL)
      TMRX(IX,IY,2)=2.*PERM(IX,IY)*THCK(IX,IY)*PERM(IX,IY+1)*THCK(IX,IY+
     11)/(PERM(IX,IY)*THCK(IX,IY)*YDEL+PERM(IX,IY+1)*THCK(IX,IY+1)*YDEL)
C     ---ADJUST COEFFICIENT FOR ANISOTROPY---
      TMRX(IX,IY,2)=TMRX(IX,IY,2)*ANFCTR
  115 CONTINUE
  119 CONTINUE
C
      IF (REMN.EQ.0.0.OR.N.EQ.NTIM.OR.IPCK.EQ.1) CALL OUTPT
      IF (IHEAD .NE. 0) GO TO 126
      CALL VELO
  101 CALL MOVE
C     **********************************************************
C     ---STORE OBS. WELL DATA FOR TRANSIENT FLOW PROBLEMS---
      IF (S.EQ.0.0) GO TO 120
      IF (NUMOBS.LE.0) GO TO 120
      J=MOD(N,50)
      IF (J.EQ.0) J=50
      TMOBS(J)=SUMT
      DO 110 I=1,NUMOBS
      TMWL(I,J)=HK(IXOBS(I),IYOBS(I))
      TMCN(I,J)=CONC(IXOBS(I),IYOBS(I))
  110 CONTINUE
C     **********************************************************
C     ---OUTPUT ROUTINES---
  120 IF (REMN.EQ.0.0.OR.N.EQ.NTIM.OR.MOD(N,50).EQ.0.OR.IPCK.EQ.1)
     1 CALL CHMOT
  126 CONTINUE
      IF (REMN.EQ.0.0.OR.N.EQ.NTIM.OR.IPCK.EQ.1) CALL GRPH
      IF (SUMT.GE.(PYR+TMSUM)) GO TO 140
  130 CONTINUE
```

```
C     ************************************************************
C     ---SUMMARY OUTPUT---
  140 CONTINUE
      NND = -1
      WRITE (10,200) NND,NND
      IPRNT=1
      IF (IHEAD .EQ. 0) CALL CHMOT
  150 CONTINUE
C     ************************************************************
C     ENDFILE(6)
C     IF (NPNCHV.EQ.0) GO TO 155
C     ENDFILE(7)
C 155 CONTINUE
      STOP
C     ************************************************************
  200 FORMAT (1H ,2I4)
      END
```

```
**** TSO FOREGROUND HARDCOPY ****
DSNAME=U11236C.KONIMOD.CNTL                           (PARLOD   )

C   USE META COMMANDS (BELOW) WHEN COMPILED ON MICROCOMPUTER
C   $NOFLOATCALLS
C   $STORAGE:2
      SUBROUTINE PARLOD                                                 B  10
      DOUBLE PRECISION DMIN1,DEXP,DLOG,DABS                             B  20
      CHARACTER*8 TITLE                                                 B  21
      REAL*8 TMRX,VPRM,HI,HR,HC,HK,WT,REC,RECH,TIM,AOPT                 B  30
      REAL*8 XDEL,YDEL,S,AREA,SUMT,RHO,PARAM,TEST,TOL,PINT,HMIN,PYR     B  40
      REAL*8 FCTR,TIMX,TINIT,PIES,YNS,XNS,RAT,HMX,HMY                   B  50
      REAL*8 TMSUM,ANTIM,TDEL                                           B  56
      REAL*8 DXINV,DYINV,ARINV,PORINV                                   B  57
      REAL*8 TINT,ALPHA1,ANITP                                          B  60
      REAL*8 HJ                                                         B  61
      INTEGER OVERRD,TP,BTM                                             B  67
      INTEGER FCON                                                      B  68
      COMMON /PRMI/ NTIM,NPMP,NPNT,NITP,N,NX,NY,NP,NREC,INT,NNX,NNY,NUMO B  70
     1BS,NMOV,IMOV,NPMAX,ITMAX,NZCRIT,IPRNT,NPTPND,NPNTMV,NPNTVL,NPNTD,N B  80
     2PNCHV,NPDELC,ICHK,FCON,IHEAD,ISOLV                                B  92
      COMMON /PRMC/ NODEID(20,20),NPCELL(20,20),NPOLD(20,20),LIMBO(500), B  95
     1IXOBS(5),IYOBS(5)                                                 B  96
     2,NDECAY,NSORB                                                     USNRC
      COMMON /HEDA/ THCK(20,20),PERM(20,20),TMWL(5,50),TMOBS(50),ANFCTR  B 120
     1,THICK(20,20)                                                     B 121
      COMMON /HEDB/ TMRX(20,20,2),VPRM(20,20),HI(20,20),HR(20,20),HC(20, B 130
     120),HK(20,20),WT(20,20),REC(20,20),RECH(20,20),TIM(100),AOPT(20),T B 140
     2ITLE(10),XDEL,YDEL,S,AREA,SUMT,RHO,PARAM,TEST,TOL,PINT,HMIN,PYR   B 150
     3,HJ(20,20)                                                        B 155
      COMMON /CHMA/ PART(3,3200),CONC(20,20),TMCN(5,50),VX(20,20),VY(20, B 160
     120),CONINT(20,20),CNRECH(20,20),POROS,SUMTCH,BETA,TIMV,STORM,STORM B 170
     2I,CMSIN,CMSOUT,FLMIN,FLMOT,SUMIO,CELDIS,DLTRAT,CSTORM             B 180
     3,DCYLAM,BLKDEN,SRBRAT,SRBSAT,SRBALF,VOLDCY,VOLSRB,SRBDCY          USNRC
      COMMON /BALM/ TOTLQ,TOTLQI,TPIN,TPOUT,TPQR                        B 187
      COMMON /XINV/ DXINV,DYINV,ARINV,PORINV                            B 200
      COMMON /CHMC/ SUMC(20,20),VXBDY(20,20),VYBDY(20,20)               B 210
      DIMENSION TEMP(5),IORDER(10)                                      B 211
      DIMENSION TRANS(20,20),BOT(20,20)                                 B 211A
      DATA IORDER/5,5,4,4,3,3,2,2,1,1/                                  B 212
C     ************************************************************      B 220
      IF (INT.GT.1) GO TO 10                                            B 230
      WRITE (6,750)                                                     B 240
      READ (5,720) TITLE                                                B 250
      WRITE (6,730) TITLE                                               B 260
      WRITE (10,735) INT,N,TITLE                                        B 265
C     ************************************************************      B 270
C     ---INITIALIZE TEST AND CONTROL VARIABLES---                       B 280
      STORMI=0.0                                                        B 290
      TEST=0.0                                                          B 300
      TPQR=0.0                                                          B 301
      TOTLQ=0.0                                                         B 310
      TOTLQI=0.0                                                        B 315
      TPIN = 0.0                                                        B 317
      TPOUT = 0.0                                                       B 318
      SUMT=0.0                                                          B 320
      SUMTCH=0.0                                                        B 330
      INT=0                                                             B 340
      IPRNT=0                                                           B 350
      NCA=0                                                             B 360
      N=0                                                               B 370
      IMOV=0                                                            B 380
      NMOV=0                                                            B 390
      ICHK = 0                                                          B 395
      VOLDCY=0.0                                                        USNRC
      VOLSRB=0.0                                                        USNRC
      SRBDCY = 0.0                                                      USNRC
C     **********************************************************        B 400
C     ---LOAD CONTROL PARAMETERS---                                     B 410
      READ (5,740) NTIM,NPMP,NX,NY,NPMAX,NPNT,NITP,NUMOBS,ITMAX,NREC,NPT B 420
     1PND,NCODES,NPNTMV,NPNTVL,NPNTD,NPDELC,NPNCHV                      B 430
      READ (5,800) PINT,TOL,POROS,BETA,S,TIMX,TINIT,XDEL,YDEL,DLTRAT,CEL B 440
     1DIS,ANFCTR                                                        B 450
      READ (5,805) NDECAY,NSORB,DCYTIM,DENROC,SORBQR,SORBST,SORBAL      USNRC
      READ (5,740) ISOLV,IHEAD,FCON,TP,BTM                              B 465
      NNX=NX-1                                                          B 470
      NNY=NY-1                                                          B 480
      NP=NPMAX                                                          B 490
      DXINV=1.0/XDEL                                                    B 500
      DYINV=1.0/YDEL                                                    B 510
      ARINV=DXINV*DYINV                                                 B 520
      PORINV=1.0/POROS                                                  B 530
      DCYLAM = 0.0                                                      USNRC
      BLKDEN = 0.0                                                      USNRC
      SRBRAT = 0.0                                                      USNRC
      SRBSAT = 0.0                                                      USNRC
      SRBALF = 0.0                                                      USNRC
      IF (NDECAY.GT.0.AND.DCYTIM.GT.0.0)                                USNRC
     1               DCYLAM = ALOG(2.0)/(365.25*86400.0*DCYTIM)         USNRC
      IF (NSORB.GT.0) BLKDEN = DENROC*(1.0-POROS)/POROS                 USNRC
      IF (NSORB.GT.0) SRBRAT = SORBQR                                   USNRC
      IF (NSORB.EQ.2) SRBSAT = SORBST                                   USNRC
      IF (NSORB.EQ.3) SRBALF = SORBAL                                   USNRC
C     ---PRINT CONTROL PARAMETERS---                                    B 540
      WRITE (6,760)                                                     B 550
      WRITE (6,770) NX,NY,XDEL,YDEL                                     B 560
      WRITE (10,785) NX,NY,NTIM,NPMP,ISOLV,IHEAD,FCON,TP,BTM,           B 564
     1      XDEL,YDEL,PINT                                              B 565
      WRITE (6,780) NTIM,NPMP,PINT,TIMX,TINIT                           B 570
      WRITE (6,790) S,POROS,BETA,DLTRAT,ANFCTR                          B 580
      IF (NDECAY.LT.1) WRITE (6,791)                                    USNRC
      IF (NDECAY.GT.0) WRITE (6,792) DCYTIM,DCYLAM                      USNRC
      IF (NSORB.LT.1) WRITE (6,793)                                     USNRC
      IF (NSORB.GT.0) WRITE (6,794) DENROC,BLKDEN                       USNRC
      IF (NSORB.EQ.1) WRITE (6,795) SRBRAT                              USNRC
      IF (NSORB.EQ.2) WRITE (6,796) SRBRAT,SRBSAT                       USNRC
      IF (NSORB.EQ.3) WRITE (6,797) SRBRAT,SRBALF                       USNRC
      IF (ISOLV.EQ.0) WRITE (6,811)                                     B 585
      IF (ISOLV.NE.0) WRITE (6,812)                                     B 586
      IF (IHEAD.NE.0) WRITE (6,813)                                     B 587
      IF (FCON.EQ.0)  WRITE (6,814)                                     B 588
      IF (FCON.NE.0)  WRITE (6,815)                                     B 589
      IF (BTM.NE.0)   WRITE (6,816)                                     B 589A
      WRITE (6,870) NITP,TOL,ITMAX,CELDIS,NPMAX,NPTPND                  B 590
      IF (NPTPND.LT.4.OR.NPTPND.GT.9.OR.NPTPND.EQ.6.OR.NPTPND.EQ.7) WRIT B 600
     1E (6,880)                                                         B 610
      IF (NITP.LT.1) WRITE (6,885)                                      B 615
      WRITE (6,890) NPNT,NPNTMV,NPNTVL,NPNTD,NUMOBS,NREC,NCODES,NPNCHV,N B 620
     1PDELC                                                             B 630
      WRITE (10,895) TOL,NUMOBS,NREC,NCODES                             B 640
      GO TO 20                                                          B 650
C     **********************************************************        B 660
C     ---READ DATA TO REVISE TIME STEPS AND STRESSES FOR SUBSEQUENT     B 670
C         PUMPING PERIODS---                                            B 680
   10 READ (5,1060) ICHK                                                B 690
      IF (ICHK.LT.1) WRITE (6,1110) INT                                 B 695
      IF (ICHK.LT.1) WRITE (10,1095) INT,N,ICHK,ICHK,ICHK               B 700
      IF (ICHK.LT.1) GO TO 20                                           B 701
      READ (5,1070) NTIM,NPNT,NITP,ITMAX,NREC,NPNTMV,NPNTVL,NPNTD,NPDELC B 710
     1,NPNCHV,PINT,TIMX,TINIT                                           B 720
      WRITE (6,1080) INT                                                B 730
      WRITE (6,1090) NTIM,NPNT,NITP,ITMAX,NREC,NPNTMV,NPNTVL,NPNTD,NPDEL
     1C,NPNCHV,PINT,TIMX,TINIT
      WRITE (10,1095) INT,N,NTIM,NREC,PINT
C     ************************************************************
C     ---LIST TIME INCREMENTS---
   20 DO 30 J=1,100
      TIM(J)=0.0
   30 CONTINUE
      PYR = PINT*86400.0*365.25
      TIM(1)=TINIT
      IF (NPNTMV.EQ.0) NPNTMV = 999
      IF (S.EQ.0.0) GO TO 50
      DO 40 K=2,NTIM
   40 TIM(K)=TIMX*TIM(K-1)
      WRITE (6,470)
      WRITE (6,490) TIM
      IF (TINIT.GT.PYR) WRITE (6,475)
      GO TO 60
   50 ANTIM = NTIM
      DO 55 K=1,NTIM
   55 TIM(K)=PYR/ANTIM
      WRITE (6,480) TIM(1)
C     ************************************************************
C     ---INITIALIZE MATRICES---
   60 IF (INT.GT.1) GO TO 100
      DO 70 IY=1,NY
      DO 70 IX=1,NX
      VPRM(IX,IY)=0.0
      PERM(IX,IY)=0.0
      TRANS(IX,IY)=0.0
      BOT(IX,IY)=0.0
      THCK(IX,IY)=0.0
      THICK(IX,IY)=0.0
      RECH(IX,IY)=0.0
      CNRECH(IX,IY)=0.0
      REC(IX,IY)=0.0
      NODEID(IX,IY)=0
      TMRX(IX,IY,1)=0.0
      TMRX(IX,IY,2)=0.0
      HI(IX,IY)=0.0
      HR(IX,IY)=0.0
      HC(IX,IY)=0.0
      HK(IX,IY)=0.0
      WT(IX,IY)=0.0
      VX(IX,IY)=0.0
      VY(IX,IY)=0.0
      VXBDY(IX,IY)=0.0
      VYBDY(IX,IY)=0.0
      CONC(IX,IY)=0.0
      CONINT(IX,IY)=0.0
      SUMC(IX,IY)=0.0
   70 CONTINUE
C     *************************************************************
C     ---READ OBSERVATION WELL LOCATIONS---
      IF (NUMOBS.LE.0) GO TO 100
      WRITE (6,900)
      DO 80 J=1,NUMOBS
      READ (5,700) IX,IY
      WRITE (6,810) J,IX,IY
      WRITE (10,1095) INT,N,IX,IY
      IXOBS(J)=IX
   80 IYOBS(J)=IY
      DO 90 I=1,NUMOBS
      DO 90 J=1,50
      TMWL(I,J)=0.0
   90 TMCN(I,J)=0.0
```

```
C     ***************************************************************
C     ---READ PUMPAGE DATA -- (X-Y COORDINATES AND RATE IN CFS)---
C        ---SIGNS : WITHDRAWAL = POS.;  INJECTION = NEG.---
C        ---IF INJ. WELL, ALSO READ CONCENTRATION OF INJECTED WATER---
  100 IF (NREC.LE.O) GO TO 120
      IF (INT.GT.1.AND.ICHK.LE.O) RETURN
      WRITE (6,910)
      DO 110 I=1,NREC
      READ (5,710) IX,IY,FCTR,CNREC
      IF (FCTR.LE.O.O) CNRECH(IX,IY)=CNREC
      REC(IX,IY)=FCTR
      WRITE (10,825) INT,N,IX,IY,REC(IX,IY),CNRECH(IX,IY)
  110 WRITE (6,820) IX,IY,REC(IX,IY),CNRECH(IX,IY)
C     ***************************************************************
  120 IF (INT.GT.1) RETURN
      AREA=XDEL*YDEL
      WRITE (6,690) AREA
      WRITE (6,600)
      WRITE (6,610) XDEL
      WRITE (6,610) YDEL
C     ***************************************************************
C     ---READ TRANS(FT**2/SEC) OR PERM(FT/SEC) INTO VPRM ARRAY---
C                ---DEPENDING ON VALUE OF TP---
C        ---FCTR = TRANS (OR PERM) MULTIPLIER  --->  FT**2/SEC---
      WRITE (6,530)
      READ (5,550) INPUT,FCTR
      DO 160 IY=1,NY
      IF (INPUT.EQ.1) READ (5,560) (VPRM(IX,IY),IX=1,NX)
      DO 150 IX=1,NX
      IF (INPUT.NE.1) GO TO 130
      VPRM(IX,IY)=VPRM(IX,IY)*FCTR
      GO TO 140
  130 VPRM(IX,IY)=FCTR
  140 IF (IX.EQ.1.OR.IX.EQ.NX) VPRM(IX,IY)=0.0
      IF (IY.EQ.1.OR.IY.EQ.NY) VPRM(IX,IY)=0.0
      IF (TP .NE. O) PERM(IX,IY)=VPRM(IX,IY)
  150 CONTINUE
  160 CONTINUE
C     ***************************************************************
C     ---READ AQUIFER THICKNESS---
      IF (BTM.EQ.O) WRITE (6,510)
      IF (BTM.NE.O) WRITE (6,520)
      READ (5,550) INPUT,FCTR
      DO 210 IY=1,NY
      IF (INPUT.EQ.1) READ (5,540) (THCK(IX,IY),IX=1,NX)
      DO 200 IX=1,NX
      IF (INPUT.NE.1) GO TO 190
      THCK(IX,IY)=THCK(IX,IY)*FCTR
      GO TO 195
  190 IF (VPRM(IX,IY).NE.O.O) THCK(IX,IY)=FCTR
  195 THICK(IX,IY)=THCK(IX,IY)
      IF (BTM.NE.O) BOT(IX,IY)=THCK(IX,IY)
  200 CONTINUE
  210 WRITE (6,500) (THCK(IX,IY),IX=1,NX)
C     ***************************************************************
C     ---READ WATER-TABLE ELEVATION---
      WRITE (6,670)
      READ (5,550) INPUT,FCTR
      DO 350 IY=1,NY
      IF (INPUT.EQ.1) READ (5,660) (WT(IX,IY),IX=1,NX)
      DO 340 IX=1,NX
      IF (INPUT.NE.1) GO TO 330
      WT(IX,IY)=WT(IX,IY)*FCTR
      GO TO 340
  330 IF (VPRM(IX,IY).NE.O.O) WT(IX,IY)=FCTR
  340 CONTINUE
  350 WRITE (6,680) (WT(IX,IY),IX=1,NX)
C         ---CALCULATE SATURATED THICKNESS---
      IF (BTM.EQ.0) GO TO 356
      WRITE (6,510)
      DO 354 IY=1,NY
      DO 352 IX=1,NX
      THCK(IX,IY)=WT(IX,IY)-THCK(IX,IY)
      THICK(IX,IY)=THCK(IX,IY)
  352 CONTINUE
  354 WRITE (6,500) (THCK(IX,IY),IX=1,NX)
  356 CONTINUE
C     ************************************************************
C     ---COMPUTE PERMEABILITY FROM TRANSMISSIVITY---
C     ---COUNT NO. OF CELLS IN AQUIFER---
C     ---SET NZCRIT = 2( OF THE NO. OF CELLS IN THE AQUIFER---
      DO 250 IX=1,NX
      DO 250 IY=1,NY
      IF (THCK(IX,IY).EQ.0.0) GO TO 250
      IF (TP .EQ. 0) PERM(IX,IY)=VPRM(IX,IY)/THCK(IX,IY)
      IF (TP .NE. 0) VPRM(IX,IY)=PERM(IX,IY)*THCK(IX,IY)
      TRANS(IX,IY)=VPRM(IX,IY)
      NCA=NCA+1
  250 CONTINUE
C
C     ---WRITE TRANSMISSIVITY---
      WRITE (6,530)
      DO 255 IY=1,NY
  255 WRITE (6,840) (VPRM(IX,IY),IX=1,NX)
C
      AAQ=NCA*AREA
      NZCRIT=(NCA+25)/50
      WRITE (6,620)
      DO 260 IY=1,NY
  260 WRITE (6,840) (PERM(IX,IY),IX=1,NX)
      WRITE (6,630) NCA,AAQ,NZCRIT
C     ************************************************************
C     ---SET UP COEFFICIENT MATRIX --- BLOCK-CENTERED GRID---
C     ---AVERAGE TRANSMISSIVITY --- HARMONIC MEAN---
C     ---MOVED SO THAT PERMEABLILTY OR TRANSMISSIVITY MAY---
C     ---BE INPUT AND CALCULATED PROPERLY---
      IF (ANFCTR.NE.0.0) GO TO 170
      WRITE (6,1050)
      ANFCTR=1.0
  170 PIES=3.1415927*3.1415927/2.0
      YNS=NY*NY
      XNS=NX*NX
      HMIN=2.0
      DO 180 IY=2,NNY
      DO 180 IX=2,NNX
      IF (VPRM(IX,IY).EQ.0.0) GO TO 180
      TMRX(IX,IY,1)=2.0*VPRM(IX,IY)*VPRM(IX+1,IY)/(VPRM(IX,IY)*XDEL+VPRM
     1(IX+1,IY)*XDEL)
      TMRX(IX,IY,2)=2.0*VPRM(IX,IY)*VPRM(IX,IY+1)/(VPRM(IX,IY)*YDEL+VPRM
     1(IX,IY+1)*YDEL)
C         ---ADJUST COEFFICIENT FOR ANISOTROPY---
      TMRX(IX,IY,2)=TMRX(IX,IY,2)*ANFCTR
C         ---COMPUTE MINIMUM ITERATION PARAMETER (HMIN)---
      IF (TMRX(IX,IY,1).EQ.0.0) GO TO 180
      IF (TMRX(IX,IY,2).EQ.0.0) GO TO 180
      RAT=TMRX(IX,IY,1)*YDEL/(TMRX(IX,IY,2)*XDEL)
      HMX=PIES/(XNS*(1.0+RAT))
      HMY=PIES/(YNS*(1.0+(1.0/RAT)))
      IF (HMX.LT.HMIN) HMIN=HMX
      IF (HMY.LT.HMIN) HMIN=HMY
  180 VPRM(IX,IY)=0.0
C     ************************************************************
```

```
C     ---READ DIFFUSE RECHARGE AND DISCHARGE---                         B2357A
      WRITE (6,830)                                                     B2357B
      READ (5,550) INPUT,FCTR                                           B2357C
      DO 240 IY=1,NY                                                    B2357D
      IF (INPUT.EQ.1) READ (5,560) (RECH(IX,IY),IX=1,NX)                B2357E
      DO 230 IX=1,NX                                                    B2358A
      IF (INPUT.NE.1) GO TO 220                                         B2358B
      RECH(IX,IY)=RECH(IX,IY)*FCTR                                      B2358C
      GO TO 230                                                         B2358D
  220 IF (THCK(IX,IY).NE.0.0) RECH(IX,IY)=FCTR                          B2358E
  230 CONTINUE                                                          B2359A
  240 WRITE (6,840) (RECH(IX,IY),IX=1,NX)                               B2359B
C     ****************************************************************  B2359C
C     ---READ NODE IDENTIFICATION CARDS---                              B2360
C        ---SET VERT. PERM., SOURCE CONC., AND DIFFUSE RECHARGE---      B2370
C           ---SPECIFY CODES TO FIT YOUR NEEDS---                       B2380
      WRITE (6,570)                                                     B2390
      READ (5,550) INPUT,FCTR                                           B2400
      DO 280 IY=1,NY                                                    B2410
      IF (INPUT.EQ.1) READ (5,640) (NODEID(IX,IY),IX=1,NX)              B2420
      DO 270 IX=1,NX                                                    B2430
  270 IF (INPUT.NE.1.AND.THCK(IX,IY).NE.0.0) NODEID(IX,IY)=FCTR         B2440
  280 WRITE (6,580) (NODEID(IX,IY),IX=1,NX)                             B2450
      WRITE (6,920) NCODES                                              B2460
      IF (NCODES.LE.0) GO TO 310                                        B2470
      WRITE (6,930)                                                     B2480
      DO 300 IJ=1,NCODES                                                B2490
      READ (5,850) ICODE,FCTR1,FCTR2,FCTR3,OVERRD                       B2500
      DO 290 IX=1,NX                                                    B2510
      DO 290 IY=1,NY                                                    B2520
      IF (NODEID(IX,IY).NE.ICODE) GO TO 290                             B2530
      VPRM(IX,IY)=FCTR1                                                 B2540
      CNRECH(IX,IY)=FCTR2                                               B2550
      IF (OVERRD.NE.0) RECH(IX,IY)=FCTR3                                B2560
  290 CONTINUE                                                          B2570
      WRITE (6,860) ICODE,FCTR1,FCTR2                                   B2580
      WRITE (10,865) INT,N,ICODE,FCTR1,FCTR2,FCTR3                      B2585
  300 IF (OVERRD.NE.0) WRITE (6,1100) FCTR3                             B2590
  310 WRITE (6,590)                                                     B2600
      DO 320 IY=1,NY                                                    B2610
  320 WRITE (6,840) (VPRM(IX,IY),IX=1,NX)                               B2621
C     ****************************************************************  B2760
C     DO 335 IY=1,NY                                                    B2761
C     DO 335 IX=1,NX                                                    B2762
  335 WRITE (10,845) INT,N,IX,IY,BOT(IX,IY),WT(IX,IY),THCK(IX,IY),      B2763
     1 TRANS(IX,IY),PERM(IX,IY),RECH(IX,IY),NODEID(IX,IY),VPRM(IX,IY)   B2764
C     ---SET INITIAL HEADS---                                           B2770
      DO 360 IX=1,NX                                                    B2780
      DO 360 IY=1,NY                                                    B2790
      HI(IX,IY)=WT(IX,IY)                                               B2800
      HC(IX,IY)=HI(IX,IY)                                               B2810
      HR(IX,IY)=HI(IX,IY)                                               B2820
  360 HK(IX,IY)=HI(IX,IY)                                               B2830
C                                                                       B2840
      CALL OUTPT                                                        B2850
C     ****************************************************************  B2860
C     ---COMPUTE ITERATION PARAMETERS---                                B2870
C     ---COMPUTE ADIP ITERATION PARAMETERS---                           B2872
      DO 370 ID=1,20                                                    B2880
      AOPT(ID)=0.0                                                      B2890
  370 CONTINUE                                                          B2900
      IF(ISOLV.NE.0) GO TO 299                                          B2902
      ANITP=NITP-1                                                      B2910
      ALPHA1 = 1.0                                                      USNRC
      IF (HMIN.LT.2.0) ALPHA1= DEXP(DLOG(1.0/HMIN)/ANITP)               USNRC
      IF (HMIN.EQ.2.0) HMIN = 0.0                                       USNRC
      AOPT(1)=HMIN                                                       B2930
      DO 380 IP=2,NITP                                                   B2940
  380 AOPT(IP)=AOPT(IP-1)*ALPHA1                                         B2950
      GO TO 401                                                          B2951A
  299 CONTINUE                                                           B2951B
C     *****************************************************************  B2952A
C       ---COMPUTE SIP ITERATION PARAMETERS---                           B2952B
      I2=NX-2                                                            B2953A
      J2=NY-2                                                            B2953B
      LENGTH=10                                                          B2954A
      W=0.0                                                              B2954B
      PI=0.0                                                             B2955A
      L2=LENGTH/2                                                        B2955B
      PL2=FLOAT(L2)-1.0                                                  B2956A
      WIDTH=FLOAT(I2)                                                    B2956B
      YDIM=FLOAT(J2)                                                     B2957A
      DX=1./WIDTH                                                        B2957B
      DY=1./YDIM                                                         B2958A
C     *****************************************************************  B2958B
C     ---COMPUTE AVERAGE MAXIMUM VALUE OF ITERATION PARAMETER---         B2959A
      DO 11 J=2,NNY                                                      B2959B
      DO 11 I=2,NNX                                                      B2960A
      PI=PI+1.0                                                          B2960B
      W=W+1.0-AMIN1(2.*DX*DX/(1.+ANFCTR*DX*DX/(DY*DY)),                  B2961C
     1             2.*DY*DY/(1.+DY*DY/(ANFCTR*DX*DX)))                   B2961D
   11 CONTINUE                                                           B2962A
      W=W/PI                                                             B2962B
C     *****************************************************************  B2963A
C     ---COMPUTE ITERATION PARAMETER IN GEOMETRIC SEQUENCE----------     B2963B
      PJ=-1.0                                                            B2964A
      DO 21 I=1,L2                                                       B2964B
      PJ=PJ+1.0                                                          B2965A
   21 TEMP(I)=1.0-(1.0-W)**(PJ/PL2)                                      B2965B
C     *****************************************************************  B2966A
C     ---ORDER SEQUENCE OF PARAMETERS---                                 B2966B
      DO 31 J=1,LENGTH                                                   B2967A
   31 AOPT(J)=TEMP(IORDER(J))                                            B2967B
  401 CONTINUE                                                           B2968A
C     ---PRINT ITERATION PARAMETERS---                                   B2968B
      WRITE (6,450)                                                      B2970
      WRITE (6,460) AOPT                                                 B2980
C     *****************************************************************  B2990
C     ---READ INITIAL CONCENTRATIONS AND COMPUTE INITIAL MASS STORED---  B3000
      READ (5,550) INPUT,FCTR                                            B3010
      DO 420 IY=1,NY                                                     B3020
      IF (INPUT.EQ.1) READ (5,660) (CONC(IX,IY),IX=1,NX)                 B3030
      DO 410 IX=1,NX                                                     B3040
      IF (INPUT.NE.1) GO TO 390                                          B3050
      CONC(IX,IY)=CONC(IX,IY)*FCTR                                       B3060
      GO TO 400                                                          B3070
  390 IF (THCK(IX,IY).NE.0.0) CONC(IX,IY)=FCTR                           B3080
  400 CONINT(IX,IY)=CONC(IX,IY)                                          B3090
  410 STORMI=STORMI+CONINT(IX,IY)*THCK(IX,IY)*AREA*POROS                 B3100
  420 CONTINUE                                                           B3110
C     *****************************************************************  B3120
C     ---CHECK DATA SETS FOR INTERNAL CONSISTENCY---                     B3130
      DO 440 IX=1,NX                                                     B3140
      DO 440 IY=1,NY                                                     B3150
      IF (RECH(IX,IY).GT.0.0) WRITE (6,935) IX,IY                        B3151
      IF (THCK(IX,IY).GT.0.0) GO TO 430                                  B3160
      IF (THCK(IX,IY).EQ.0.0) GO TO 434                                  B3162
      WRITE (6,945) IX,IY                                                B3164
      GO TO 440                                                          B3166
  434 CONTINUE                                                           B3168
      IF (TMRX(IX,IY,1).GT.0.0) WRITE (6,940) IX,IY                      B3170
      IF (TMRX(IX,IY,2).GT.0.0) WRITE (6,950) IX,IY                      B3180
      IF (NODEID(IX,IY).GT.0) WRITE (6,960) IX,IY
      IF (WT(IX,IY).NE.0.0) WRITE (6,970) IX,IY
      IF (RECH(IX,IY).NE.0.0) WRITE (6,980) IX,IY
      IF (REC(IX,IY).NE.0.0) WRITE (6,990) IX,IY
  430 IF (PERM(IX,IY).GT.0.0) GO TO 440
      IF (NODEID(IX,IY).GT.0.0) WRITE (6,1000) IX,IY
      IF (WT(IX,IY).NE.0.0) WRITE (6,1010) IX,IY
      IF (RECH(IX,IY).NE.0.0) WRITE (6,1020) IX,IY
      IF (REC(IX,IY).NE.0.0) WRITE (6,1030) IX,IY
      IF (THCK(IX,IY).GT.0.0) WRITE (6,1040) IX,IY
  440 CONTINUE
C     ***********************************************************
      RETURN
C     ***********************************************************
C
C
C
  450 FORMAT (1H1,20HITERATION PARAMETERS)
  460 FORMAT (1H ,/, 1P8E10.3/ 1P8E10.3)
  470 FORMAT (1H1,27HTIME INTERVALS (IN SECONDS))
  475 FORMAT (1H0,5X,65H*** WARNING ***   INITIAL TIME STEP IS LONGER TH
     1AN PUMPING PERIOD/25X,34H***ADJUST EITHER TINIT OR PINT.***/)
  480 FORMAT (1H1,15X,17HSTEADY-STATE FLOW//5X,57HTIME INTERVAL (IN SEC)
     1 FOR SOLUTE-TRANSPORT SIMULATION = ,1P1E12.5)
  490 FORMAT (3H    ,10G12.5)
  500 FORMAT (3H    ,20F5.1)
  510 FORMAT (1H1,22HAQUIFER THICKNESS (FT))
  520 FORMAT (1H1,19HAQUIFER BOTTOM (FT))
  530 FORMAT (1H1,30HTRANSMISSIVITY MAP (FT*FT/SEC))
  540 FORMAT (26G3.0)
  550 FORMAT (I1,G10.0)
  560 FORMAT (20G4.1)
  570 FORMAT (1H1,23HNODE IDENTIFICATION MAP//)
  580 FORMAT (1H ,20I5)
  590 FORMAT (1H1,45HVERTICAL PERMEABILITY/THICKNESS (FT/(FT*SEC)))
  600 FORMAT (1H0,10X,12HX-Y SPACING: )
  610 FORMAT (1H ,12X,10G12.5)
  620 FORMAT (1H1,24HPERMEABILTY MAP (FT/SEC))
  630 FORMAT (1H0,////10X,44HNO. OF FINITE-DIFFERENCE CELLS IN AQUIFER =
     1 ,I4//10X,28HAREA OF AQUIFER IN MODEL   = ,1P1E12.5,8H SQ. FT.////1
     20X,47HNZCRIT   (MAX. NO. OF CELLS THAT CAN BE VOID OF/20X,56HPARTI
     3CLES:  IF EXCEEDED, PARTICLES ARE REGENERATED)    = ,I4/)
  640 FORMAT (80I1)
  660 FORMAT (20G4.0)
  670 FORMAT (1H1,11HWATER TABLE)
  680 FORMAT (1H ,20F5.0)
  690 FORMAT (1H0,10X,19HAREA OF ONE CELL = ,1P1E12.4)
  700 FORMAT (2I2)
  710 FORMAT (2I2,2G8.2)
  720 FORMAT (10A8)
  730 FORMAT (1H0,10A8)
  735 FORMAT (1H ,2I4/10A8)
  740 FORMAT (17I4)
  750 FORMAT (1H1,77HU.S.G.S. METHOD-OF-CHARACTERISTICS MODEL FOR SOLUTE
     1 TRANSPORT IN GROUND WATER)
  760 FORMAT (1H0,21X,21HI N P U T     D A T A)
  770 FORMAT (1H0,23X,16HGRID DESCRIPTORS//13X,30HNX      (NUMBER OF COLUM
     1NS)  =   ,I4/13X,28HNY     (NUMBER OF ROWS)      =,I6/13X,29HXDEL   (X
     2-DISTANCE IN FEET) = ,F7.1/13X,29HYDEL  (Y-DISTANCE IN FEET) = ,F7
     3.1)
  780 FORMAT (1H0,23X,16HTIME  PARAMETERS//13X,40HNTIM    (MAX. NO. OF TI
     1ME STEPS)       = ,I6/13X,40HNPMP    (NO. OF PUMPING PERIODS)
     2 = ,I6/13X,39HPINT    (PUMPING PERIOD IN YEARS)       =,F11.3/13X,39
     3HTIMX    (TIME INCREMENT MULTIPLIER)     =,F10.2/13X,39HTINIT   (INIT
     4IAL TIME STEP IN SEC.)     =,G10.2)
  785 FORMAT (1H ,9I4,3F11.3)
```

```
790 FORMAT (1HO,14X,34HHYDROLOGIC AND CHEMICAL PARAMETERS//13X,1HS,7X,  B3820
   129H(STORAGE COEFFICIENT)        =,5X,F9.6/13X,28HPOROS   (EFFECTIVE  B3830
   2 POROSITY),8X,3H=  ,F8.2/13X,39HBETA    (CHARACTERISTIC LENGTH)      B3840
   3  =  ,F7.1/13X,31HDLTRAT  (RATIO OF TRANSVERSE TO/21X,30HLONGITUDI  B3850
   4NAL DISPERSIVITY)  = ,F9.2/13X,39HANFCTR  (RATIO OF T-YY TO T-XX)    B3860
   5    =  ,F12.6)                                                       B3870
791 FORMAT (1HO,1X,26H***NON-DECAYING SPECIES***)                        USNRC
792 FORMAT (1HO,1X,28HSPECIES HALF LIFE (YEARS) = ,1P1E10.3,             USNRC
   1         30H OR DECAY CONSTANT (1/SECS) = ,1P1E10.3)                 USNRC
793 FORMAT (1HO,1X,25H***NON-SORBING SPECIES***)                         USNRC
734 FORMAT (1HO,1X,27HROCK DENSITY (GRM/CM**3) = ,1P1E10.3,              USNRC
   1                 24HBULK DENSITY/POROSITY = ,1P1E10.3)               USNRC
795 FORMAT (1HO,1X,21H***LINEAR SORBTION***,                             USNRC
   1              1X,29HDISTRIBUTION CONSTANT (KD) = ,1P1E10.3)          USNRC
796 FORMAT (1HO,1X,23H***LANGMUIR ISOTHERM***,                           USNRC
   1              1X,16HRATE CONSTANT = ,1P1E10.3,                       USNRC
   2              1X,22HSATURATION CONSTANT = ,1P1E10.3)                 USNRC
797 FORMAT (1HO,1X,25H***FREUNDLICH ISOTHERM***,                         USNRC
   1              1X,16HRATE CONSTANT = ,1P1E10.3,                       USNRC
   2              1X,19HEXPONENT (ALPHA) = ,1P1E10.3)                    USNRC
800 FORMAT (12G5.0)                                                      B3880
805 FORMAT (2I5,5G10.0)                                                  USNRC
810 FORMAT (1H ,16X,I2,5X,I2,4X,I2)                                      B3890
811 FORMAT (1HO,1X,15H***ADIP USED***)                                   B3891A
812 FORMAT (1HO,1X,14H***SIP USED***)                                    B3891B
813 FORMAT (1HO,1X,26H***HEAD ONLY SIMULATION***)                        B3891C
814 FORMAT (1HO,1X,22H***CONFINED AQUIFER***)                            B3891D
815 FORMAT (1HO,1X,24H***UNCONFINED AQUIFER***)                          B3891E
816 FORMAT (1HO,1X,18H***BOTTOM INPUT***)                                B3891F
820 FORMAT (1H ,7X,2I4,3X,E9.3,3X,F8.2)                                  B3895
825 FORMAT (1H ,4I4,2E9.3)                                               B3900
830 FORMAT (1H1,39HDIFFUSE RECHARGE AND DISCHARGE (FT/SEC))              B3910
840 FORMAT (1H ,1P10E10.2)                                               B3920
845 FORMAT (1H ,4I4/3F10.4,3E10.2,I10,E10.2)                             B3925
850 FORMAT (I2,3G10.2,I2)                                                B3930
860 FORMAT (1HO,7X,I2,7X,1P1E10.3,4X,1P1E10.3)                           B3940
865 FORMAT (1H ,3I4,1P3E10.3)                                            B3945
870 FORMAT (1HO,21X,20HEXECUTION PARAMETERS//13X,39HNITP   (NO. OF ITE  B3950
   1R. PARAM  - ADIP) = ,I4/13X,39HTOL    (CONVERGENCE CRITERIA)         B3965
   2   = ,F9.4/13X,39HITMAX  (MAX.NO.OF ITERATIONS)        = ,I4/13X,3   B3975
   34HCELDIS (MAX.CELL DISTANCE PER MOVE/24X,28HOF PARTICLES - M.O.C.)   B3980
   4    = ,F8.3/13X,30HNPMAX  (MAX. NO. OF PARTICLES),7X,2H= ,I4/12X,3   B3990
   52H NPTPND (NO. PARTICLES PER NODE),6X,3H=  ,I4)                      B4000
880 FORMAT (1HO,5X,47H*** WARNING ***  NPTPND MUST EQUAL 4,5,8, OR 9.)   B4010
885 FORMAT (1HO,5X,38H*** WARNING ***  NITP MUST BE POSITIVE)            B4015
890 FORMAT (1HO,23X,15HPROGRAM OPTIONS//13X,30HNPNT   (TIME STEP INTER  B4020
   1VAL FOR/21X,18HCOMPLETE PRINTOUT),7X,3H=  ,I4/13X,31HNPNTMV (MOVE    B4030
   2INTERVAL FOR CHEM./21X,28HCONCENTRATION PRINTOUT)  =  ,I4/13X,29HN   B4040
   3PNTVL (PRINT OPTION-VELOCITY/21X,24HO=NO; 1=FIRST TIME STEP;/21X,1   B4050
   47H2=ALL TIME STEPS),8X,3H=  ,I4/13X,31HNPNTD  (PRINT OPTION-DISP.C   B4060
   5OEF./21X,24HO=NO; 1=FIRST TIME STEP;/21X,17H2=ALL TIME STEPS),8X,3   B4070
   6H=  ,I4/13X,32HNUMOBS (NO. OF OBSERVATION WELLS/21X,28HFOR HYDROGR   B4080
   7APH PRINTOUT) =  ,I4/13X,35HNREC   (NO. OF PUMPING WELLS)    = ,I5   B4090
   8/13X,24HNCODES (FOR NODE IDENT.).9X,2H= ,I5/13X,25HNPNCHV (PUNCH V   B4100
   9ELOCITIES),8X,2H= ,I5/13X,36HNPDELC (PRINT OPT.-CONC. CHANGE) =  ,   B4110
   $I4)                                                                  B4120
895 FORMAT (1H ,F9.4,3I4)                                                B4125
900 FORMAT (1HO,10X,29HLOCATION OF OBSERVATION WELLS//17X,3HNO.,5X,1HX   B4130
   1,5X,1HY/)                                                            B4140
910 FORMAT (1HO,10X,28HLOCATION  OF  PUMPING  WELLS//11X,28HX    Y   RA  B4150
   1TE(IN CFS)   CONC./)                                                 B4160
920 FORMAT (1HO,5X,37HNO. OF NODE IDENT. CODES SPECIFIED = ,I2)          B4170
930 FORMAT (1HO,10X,41HTHE FOLLOWING ASSIGNMENTS HAVE BEEN MADE:/5X,51   B4180
   1HCODE NO.     LEAKANCE      SOURCE CONC.      RECHARGE)              B4190
935 FORMAT (1H ,5X,42H*** WARNING ***   RECH.GT.0.0 AT NODE IX =,I4,     B4191
   1 6H, IY =,I4)                                                        B4192
```

```
  940 FORMAT (1H ,5X,61H*** WARNING ***   THCK.EQ.0.0 AND TMRX(X).GT.0.0  B4200
     1 AT NODE IX =,I4,6H, IY =,I4)                                       B4210
  945 FORMAT (1H ,5X,42H*** WARNING ***   THCK.LT.0.0 AT NODE IX =,I4,    B4212
     1 6H, IY =,I4)                                                       B4214
  950 FORMAT (1H ,5X,61H*** WARNING ***   THCK.EQ.0.0 AND TMRX(Y).GT.0.0  B4220
     1 AT NODE IX =,I4,6H, IY =,I4)                                       B4230
  960 FORMAT (1H ,5X,61H*** WARNING ***    THCK.EQ.0.0 AND NODEID.GT.0.0  B4240
     1 AT NODE IX =,I4,6H, IY =,I4)                                       B4250
  970 FORMAT (1H ,5X,56H*** WARNING ***   THCK.EQ.0.0 AND WT.NE.0.0 AT N  B4260
     1ODE IX =,I4,6H, IY =,I4)                                            B4270
  980 FORMAT (1H ,5X,58H*** WARNING ***   THCK.EQ.0.0 AND RECH.NE.0.0 AT  B4280
     1 NODE IX =,I4,6H, IY =,I4)                                          B4290
  990 FORMAT (1H ,5X,58H*** WARNING ***    THCK.EQ.0.0 AND REC.NE.0.0 AT  B4300
     1 NODE IX =,I4,6H, IY =,I4)                                          B4310
 1000 FORMAT (1H ,5X,61H*** WARNING ***    PERM.EQ.0.0 AND NODEID.GT.0.0  B4320
     1 AT NODE IX =,I4,6H, IY =,I4)                                       B4330
 1010 FORMAT (1H ,5X,56H*** WARNING ***   PERM.EQ.0.0 AND WT.NE.0.0 AT N  B4340
     1ODE IX =,I4,6H, IY =,I4)                                            B4350
 1020 FORMAT (1H ,5X,58H*** WARNING ***   PERM.EQ.0.0 AND RECH.NE.0.0 AT  B4360
     1 NODE IX =,I4,6H, IY =,I4)                                          B4370
 1030 FORMAT (1H ,5X,58H*** WARNING ***    PERM.EQ.0.0 AND REC.NE.0.0 AT  B4380
     1 NODE IX =,I4,6H, IY =,I4)                                          B4390
 1040 FORMAT (1H ,5X,58H*** WARNING ***   PERM.EQ.0.0 AND THCK.GT.0.0 AT  B4400
     1 NODE IX =,I4,6H, IY =,I4)                                          B4410
 1050 FORMAT (1H0,5X,45H*** WARNING ***   ANFCTR WAS SPECIFIED AS 0.0/23  B4420
     1X,34HDEFAULT ACTION: RESET ANFCTR = 1.0)                            B4430
 1060 FORMAT (I1)                                                         B4440
 1070 FORMAT (10I4,3G5.0)                                                 B4450
 1080 FORMAT (1H1,5X,25HSTART PUMPING PERIOD NO. ,I2//2X,75HTHE FOLLOWIN  B4460
     1G TIME STEP, PUMPAGE, AND PRINT PARAMETERS HAVE BEEN REDEFINED:/)   B4470
 1090 FORMAT (1H0,14X,9HNTIM    = ,I4/15X,9HNPNT    = ,I4/15X,9HNITP    = ,B4480
     1I4/15X,9HITMAX   = ,I4/15X,9HNREC    = ,I4/15X,9HNPNTMV  = ,I4/15X,9H B4490
     2NPNTVL  = ,I4/15X,9HNPNTD   = ,I4/15X,9HNPDELC  = ,I4/15X,9HNPNCHV =  B4500
     3,I4/15X,9HPINT    = ,F10.3/15X,9HTIMX    = ,F10.3/15X,9HTINIT   = ,F1 B4510
     40.3/)                                                               B4520
 1095 FORMAT (1H ,4I4,F11.3)                                              B4525
 1100 FORMAT (1H ,46X,1P1E10.3)                                           B4530
 1110 FORMAT (1H1,5X,25HSTART PUMPING PERIOD NO. ,I2//2X,                 B4532
     1                 23HNO PARAMETERS REDEFINED/)                       B4533
      END                                                                 B4540-
```

```
**** TSO FOREGROUND HARDCOPY ****
DSNAME=U11236C.KONIMOD.CNTL                            (ITERAT  )

C  USE META COMMANDS (BELOW) WHEN COMPILED ON MICROCOMPUTER
C  $NOFLOATCALLS
C  $STORAGE:2
      SUBROUTINE ITERAT                                                 C  10
      CHARACTER*8 TITLE                                                 C  11
      REAL*8 TMRX,VPRM,HI,HR,HC,HK,WT,REC,RECH,TIM,AOPT                 C  30
      REAL*8 XDEL,YDEL,S,AREA,SUMT,RHO,PARAM,TEST,TOL,PINT,HMIN,PYR     C  40
      REAL*8 DXINV,DYINV,ARINV,PORINV                                   C  45
      REAL*8 HJ                                                         C  46
      REAL*8 B,G,W,A,C,E,F,DR,DC,TBAR,TMK,COEF,BLH,BRK,CHK,QL,BRH       C  50
      INTEGER FCON                                                      C  51
      COMMON /PRMI/ NTIM,NPMP,NPNT,NITP,N,NX,NY,NP,NREC,INT,NNX,NNY,NUMO C  60
     1BS,NMOV,IMOV,NPMAX,ITMAX,NZCRIT,IPRNT,NPTPND,NPNTMV,NPNTVL,NPNTD,N C  70
     2PNCHV,NPDELC,ICHK,FCON,IHEAD,ISOLV                                C  82
      COMMON /PRMC/ NODEID(20,20),NPCELL(20,20),NPOLD(20,20),LIMBO(500), C  85
     1IXOBS(5),IYOBS(5)                                                 C  86
     2,NDECAY,NSORB                                                     USNRC
      COMMON /HEDA/ THCK(20,20),PERM(20,20),TMWL(5,50),TMOBS(50),ANFCTR C 110
     1,THICK(20,20)                                                     C 111
      COMMON /HEDB/ TMRX(20,20,2),VPRM(20,20),HI(20,20),HR(20,20),HC(20, C 120
     120),HK(20,20),WT(20,20),REC(20,20),RECH(20,20),TIM(100),AOPT(20),T C 130
     2ITLE(10),XDEL,YDEL,S,AREA,SUMT,RHO,PARAM,TEST,TOL,PINT,HMIN,PYR   C 140
     3,HJ(20,20)                                                        C 145
      COMMON /BALM/ TOTLQ,TOTLQI,TPIN,TPOUT,TPQR                        C 147
      COMMON /XINV/ DXINV,DYINV,ARINV,PORINV                            C 160
      DIMENSION W(20), B(20), G(20)                                     C 170
C     ************************************************************     C 180
      KOUNT=0                                                           C 190
      PQIN = 0.0                                                        C 192
      PQOUT = 0.0                                                       C 193
      PQR = 0.0                                                         C 194
C     ---COMPUTE ROW AND COLUMN---                                      C 200
C        ---CALL NEW ITERATION PARAMETER---                             C 210
   10 REMN=MOD(KOUNT,NITP)                                              C 220
      IF (REMN.EQ.0) NTH=0                                              C 230
      NTH=NTH+1                                                         C 240
      PARAM=AOPT(NTH)                                                   C 250
C     ************************************************************     C 260
C     ---ROW COMPUTATIONS---                                            C 270
      TEST=0.0                                                          C 280
      RHO=S/TIM(N)                                                      C 290
      BRK=-RHO                                                          C 300
      DO 50 IY=1,NY                                                     C 310
      DO 20 M=1,NX                                                      C 320
      W(M)=0.0                                                          C 330
      B(M)=0.0                                                          C 340
      G(M)=0.0                                                          C 350
   20 CONTINUE                                                          C 360
      DO 30 IX=1,NX                                                     C 370
      IF (THCK(IX,IY).EQ.0.0) GO TO 30                                  C 380
      COEF=VPRM(IX,IY)                                                  C 390
      QL=-COEF*WT(IX,IY)                                                C 400
      A=TMRX(IX-1,IY,1)*DXINV                                           C 410
      C=TMRX(IX,IY,1)*DXINV                                             C 420
      E=TMRX(IX,IY-1,2)*DYINV                                           C 430
      F=TMRX(IX,IY,2)*DYINV                                             C 440
      TBAR=A+C+E+F                                                      C 450
      TMK=TBAR*PARAM                                                    C 460
      BLH=-A-C-RHO-COEF-TMK                                             C 470
      IF (A.EQ.0.0.AND.C.EQ.0.0.AND.RHO.EQ.0.0.AND.COEF.EQ.0.0.AND.     USNRC
     1    TMK.EQ.0.0) GO TO 30                                          USNRC
      BRH=E+F-TMK                                                       C 480
      DR=BRH*HC(IX,IY)+BRK*HK(IX,IY)-E*HC(IX,IY-1)-F*HC(IX,IY+1)+QL+RECH
     1(IX,IY)+REC(IX,IY)*ARINV
      W(IX)=BLH-A*B(IX-1)
      B(IX)=C/W(IX)
      G(IX)=(DR-A*G(IX-1))/W(IX)
   30 CONTINUE
C
C        ---BACK SUBSTITUTION---
      DO 40 J=2,NX
      IJ=J-1
      IS=NX-IJ
      HR(IS,IY)=G(IS)-B(IS)*HR(IS+1,IY)
   40 IF (W(IS).EQ.0.0) HR(IS,IY) = HC(IS,IY)
   50 CONTINUE
C     ***************************************************************
C     ---COLUMN COMPUTATIONS---
      DO 90 IX=1,NX
      DO 60 M=1,NY
      W(M)=0.0
      B(M)=0.0
   60 G(M)=0.0
      DO 70 IY=1,NY
      IF (THCK(IX,IY).EQ.0.0) GO TO 70
      COEF=VPRM(IX,IY)
      QL=-COEF*WT(IX,IY)
      A=TMRX(IX,IY-1,2)*DYINV
      C=TMRX(IX,IY,2)*DYINV
      E=TMRX(IX-1,IY,1)*DXINV
      F=TMRX(IX,IY,1)*DXINV
      TBAR=A+C+E+F
      TMK=TBAR*PARAM
      BLH=-A-C-RHO-COEF-TMK
      IF (A.EQ.0.0.AND.C.EQ.0.0.AND.RHO.EQ.0.0.AND.COEF.EQ.0.0.AND.
     1    TMK.EQ.0.0) GO TO 70
      BRH=E+F-TMK
      DC=BRH*HR(IX,IY)+BRK*HK(IX,IY)-E*HR(IX-1,IY)-F*HR(IX+1,IY)+QL+RECH
     1(IX,IY)+REC(IX,IY)*ARINV
      W(IY)=BLH-A*B(IY-1)
      B(IY)=C/W(IY)
      G(IY)=(DC-A*G(IY-1))/W(IY)
   70 CONTINUE
C
C        ---BACK SUBSTITUTION---
      DO 80 J=2,NY
      IJ=J-1
      IB=NY-IJ
      HC(IX,IB)=G(IB)-B(IB)*HC(IX,IB+1)
      IF (W(IB).EQ.0.0) HC(IX,IB) = HR(IX,IB)
      IF (THCK(IX,IB).EQ.0.0) GO TO 80
      CHK=DABS(HC(IX,IB)-HR(IX,IB))
      IF (CHK.GT.TOL) TEST=1.0
   80 CONTINUE
   90 CONTINUE
C     ***************************************************************
      KOUNT=KOUNT+1
      IF (TEST.EQ.0.0) GO TO 120
      IF (KOUNT.GE.ITMAX) GO TO 100
      GO TO 10
C     ****************************************************************
C     ---TERMINATE PROGRAM -- ITMAX EXCEEDED---
  100 WRITE (6,160)
      DO 110 IX=1,NX
      DO 110 IY=1,NY
  110 HK(IX,IY)=HC(IX,IY)
      CALL OUTPT
      STOP
```

```
C     ***********************************************************
C     ---SET NEW HEAD (HK)---
  120 DO 130 IY=1,NY
      DO 130 IX=1,NX
      IF (THCK(IX,IY).EQ.0.0) GO TO 130
      HR(IX,IY)=HK(IX,IY)
      HK(IX,IY)=HC(IX,IY)
C
C     ---CUMULATIVE PUMPAGE AND RECHARGE FOR MASS BALANCE---
      IF (REC(IX,IY).GT.0.0) GO TO 32
      PQIN = PQIN + REC(IX,IY)
      GO TO 34
   32 PQOUT = PQOUT + REC(IX,IY)
   34 IF (RECH(IX,IY).GT.0.0) GO TO 36
      PQR = PQR + RECH(IX,IY)*AREA
      GO TO 38
   36 PQOUT = PQOUT + RECH(IX,IY)*AREA
C     ---COMPUTE LEAKAGE FOR MASS BALANCE---
   38 IF (VPRM(IX,IY).EQ.0.0) GO TO 130
      DELQ=-VPRM(IX,IY)*AREA*(WT(IX,IY)-HK(IX,IY))
      IF (DELQ.LE.0.0) GO TO 125
      TOTLQ=TOTLQ+DELQ*TIM(N)
      GO TO 130
  125 TOTLQI=TOTLQI+DELQ*TIM(N)
  130 CONTINUE
      TPIN = TPIN + PQIN*TIM(N)
      TPQR = TPQR + PQR*TIM(N)
      TPOUT = TPOUT + PQOUT*TIM(N)
C
      WRITE (6,140) N
      WRITE (6,150) KOUNT
C     ***********************************************************
      RETURN
C     ***********************************************************
C
C
C
  140 FORMAT (1H0//3X,4HN = ,1I4)
  150 FORMAT (1H ,2X,23HNUMBER OF ITERATIONS = ,1I4)
  160 FORMAT (1H0,5X,64H***   EXECUTION TERMINATED -- MAX. NO. ITERATION
     1S EXCEEDED    ***/26X,21HFINAL OUTPUT FOLLOWS:)
      END
```

```
**** TSO FOREGROUND HARDCOPY ****
DSNAME=U11236C.KONIMOD.CNTL                         (GENPT    )

C  USE META COMMANDS (BELOW) WHEN COMPILED ON MICROCOMPUTER
C  $NOFLOATCALLS
C  $STORAGE:2
      SUBROUTINE GENPT                                                  D  10
      CHARACTER*8 TITLE                                                 D  11
      REAL*8 TMRX,VPRM,HI,HR,HC,HK,WT,REC,RECH,TIM,AOPT                 D  20
      REAL*8 XDEL,YDEL,S,AREA,SUMT,RHO,PARAM,TEST,TOL,PINT,HMIN,PYR     D  30
      REAL*8 HJ                                                         D  34
      INTEGER  PTID                                                     D  35
      INTEGER  FCON                                                     D  36
      COMMON /PRMI/ NTIM,NPMP,NPNT,NITP,N,NX,NY,NP,NREC,INT,NNX,NNY,NUMO D  40
     1BS,NMOV,IMOV,NPMAX,ITMAX,NZCRIT,IPRNT,NPTPND,NPNTMV,NPNTVL,NPNTD,N D  50
     2PNCHV,NPDELC,ICHK,FCON,IHEAD,ISOLV                                D  62
      COMMON /PRMC/ NODEID(20,20),NPCELL(20,20),NPOLD(20,20),LIMBO(500), D  65
     1IXOBS(5),IYOBS(5)                                                 D  66
     2,NDECAY,NSORB                                                     USNRC
      COMMON /HEDA/ THCK(20,20),PERM(20,20),TMWL(5,50),TMOBS(50),ANFCTR D  90
     1,THICK(20,20)                                                     D  91
      COMMON /HEDB/ TMRX(20,20,2),VPRM(20,20),HI(20,20),HR(20,20),HC(20, D 100
     120),HK(20,20),WT(20,20),REC(20,20),RECH(20,20),TIM(100),AOPT(20),T D 110
     2ITLE(10),XDEL,YDEL,S,AREA,SUMT,RHO,PARAM,TEST,TOL,PINT,HMIN,PYR   D 120
     3,HJ(20,20)                                                        D 125
      COMMON /CHMA/ PART(3,3200),CONC(20,20),TMCN(5,50),VX(20,20),VY(20, D 130
     120),CONINT(20,20),CNRECH(20,20),POROS,SUMTCH,BETA,TIMV,STORM,STORM D 140
     2I,CMSIN,CMSOUT,FLMIN,FLMOT,SUMIO,CELDIS,DLTRAT,CSTORM             D 150
     3,DCYLAM,BLKDEN,SRBRAT,SRBSAT,SRBALF,VOLDCY,VOLSRB,SRBDCY          USNRC
      COMMON /CHMP/ PTID(3200)                                          D 155
      DIMENSION RP(8), RN(8), IPT(8)                                    D 160
C     **************************************************************    D 170
      F1=0.30                                                           D 180
      F2=1.0/3.0                                                        D 190
      IF (NPTPND.EQ.4) F1=0.25                                          D 200
      IF (NPTPND.EQ.9) F1=1.0/3.0                                       D 210
      IF (NPTPND.EQ.8) F2=0.25                                          D 220
      NCHK=NPTPND                                                       D 230
      IF (NPTPND.EQ.5.OR.NPTPND.EQ.9) NCHK=NPTPND-1                     D 240
      IF (TEST.GT.98.) GO TO 10                                         D 250
C     **************************************************************    D 260
C     ---INITIALIZE VALUES---                                           D 270
      STORM=0.0                                                         D 280
      CMSIN=0.0                                                         D 290
      CMSOUT=0.0                                                        D 300
      FLMIN=0.0                                                         D 310
      FLMOT=0.0                                                         D 320
      SUMIO=0.0                                                         D 330
C     **************************************************************    D 340
   10 DO 20 IN=1,NPMAX                                                  D 345
      PTID(IN)=0                                                        D 355
      DO 20 ID=1,3                                                      D 365
   20 PART(ID,IN)=0.0                                                   D 370
      DO 30 IA=1,8                                                      D 380
      RP(IA)=0.0                                                        D 390
      RN(IA)=0.0                                                        D 400
   30 IPT(IA)=0                                                         D 410
C     ---SET UP LIMBO ARRAY---                                          D 420
      DO 40 IN=1,500                                                    D 430
   40 LIMBO(IN)=0.0                                                     D 440
      IND=1                                                             D 450
      DO 50 IL=1,500,2                                                  D 460
      LIMBO(IL)=IND                                                     D 470
   50 IND=IND+1                                                         D 480
C     **************************************************************    D 490
```

```
C     ---INSERT PARTICLES---
      DO 410 IX=1,NX
      DO 410 IY=1,NY
      IF (THCK(IX,IY).EQ.0.0) GO TO 410
      KR=0
      TEST2=0.0
      METH=1
      NPCELL(IX,IY)=0
      NPOLD(IX,IY)=NPTPND
      C1=CONC(IX,IY)
      IF (C1.LE.1.0E-05) TEST2=1.0
      IF (VPRM(IX,IY).GT.0.09) TEST2=1.0
      IF (REC(IX,IY).NE.0.0) TEST2=1.0
      IF (THCK(IX+1,IY+1).EQ.0.0.OR.THCK(IX+1,IY-1).EQ.0.0.OR.THCK(IX-1,
     1IY+1).EQ.0.0.OR.THCK(IX-1,IY-1).EQ.0.0) TEST2=1.0
      IF ((THCK(IX,IY+1).EQ.0.0.OR.THCK(IX,IY-1).EQ.0.0.OR.THCK(IX+1,IY)
     1.EQ.0.0.OR.THCK(IX-1,IY).EQ.0.0).AND.NPTPND.GT.5) TEST2=1.0
      CNODE=C1*(1.0-F1)
      IF (TEST.LT.98.0.OR.TEST2.GT.0.0) GO TO 70
      SUMC=CONC(IX+1,IY)+CONC(IX-1,IY)+CONC(IX,IY+1)+CONC(IX,IY-1)
      IF (NCHK.EQ.4) GO TO 60
      SUMC=SUMC+CONC(IX+1,IY+1)+CONC(IX+1,IY-1)+CONC(IX-1,IY+1)+CONC(IX-
     11,IY-1)
   60 AVC=SUMC/NCHK
      IF (AVC.GT.C1) METH=2
C
C        ---PUT 4 PARTICLES ON CELL DIAGONALS---
   70 DO 140 IT=1,2
      EVET=(-1.0)**IT
      DO 140 IS=1,2
      EVES=(-1.0)**IS
      PART(1,IND)=IX+F1*EVET
      PART(2,IND)=IY+F1*EVES
      PART(2,IND)=-PART(2,IND)
      PART(3,IND)=C1
      KR=KR+1
      PTID(IND)=KR
      IF (TEST.LT.98.0.OR.TEST2.GT.0.0) GO TO 130
      IXD=IX+EVET
      IYD=IY+EVES
      IPT(KR)=IND
      IF (METH.EQ.2) GO TO 80
      PART(3,IND)=CNODE+CONC(IXD,IYD)*F1
      GO TO 90
   80 PART(3,IND)=2.0*C1*CONC(IXD,IYD)/(C1+CONC(IXD,IYD))
   90 IF (C1-CONC(IXD,IYD)) 100,110,120
  100 RP(KR)=CONC(IXD,IYD)-PART(3,IND)
      RN(KR)=C1-PART(3,IND)
      GO TO 130
  110 RP(KR)=0.0
      RN(KR)=0.0
      GO TO 130
  120 RP(KR)=C1-PART(3,IND)
      RN(KR)=CONC(IXD,IYD)-PART(3,IND)
  130 IND=IND+1
  140 CONTINUE
C
      IF (NPTPND.EQ.5.OR.NPTPND.EQ.9) GO TO 150
      GO TO 160
C        ---PUT ONE PARTICLE AT CENTER OF CELL---
  150 PART(1,IND)=IX
      PART(2,IND)=-IY
      PART(3,IND)=C1
      PTID(IND)=5
      IND=IND+1
C        ---PLACE NORTH, SOUTH, EAST, AND WEST PARTICLES---
```

```
  160 IF (NPTPND.LT.8) GO TO 290
      CNODE=C1*(1.0-F2)
      DO 280 IT=1,2
      EVET=(-1.0)**IT
      PART(1,IND)=IX+F2*EVET
      PART(2,IND)=-IY
      PART(3,IND)=C1
      IF (EVET.LT.0) PTID(IND)=6
      IF (EVET.GT.0) PTID(IND)=8
      IF (TEST.LT.98.0.OR.TEST2.GT.0.0) GO TO 220
      IXD=IX+EVET
      KR=KR+1
      IPT(KR)=IND
      IF (METH.EQ.2) GO TO 170
      PART(3,IND)=CNODE+CONC(IXD,IY)*F2
      GO TO 180
  170 PART(3,IND)=2.0*C1*CONC(IXD,IY)/(C1+CONC(IXD,IY))
  180 IF (C1-CONC(IXD,IY)) 190,200,210
  190 RP(KR)=CONC(IXD,IY)-PART(3,IND)
      RN(KR)=C1-PART(3,IND)
      GO TO 220
  200 RP(KR)=0.0
      RN(KR)=0.0
      GO TO 220
  210 RP(KR)=C1-PART(3,IND)
      RN(KR)=CONC(IXD,IY)-PART(3,IND)
      PART(1,IND)=IX
  220 IND=IND+1
      PART(2,IND)=IY+F2*EVET
      PART(2,IND)=-PART(2,IND)
      PART(3,IND)=C1
      IF (EVET.LT.0) PTID(IND)=7
      IF (EVET.GT.0) PTID(IND)=9
      IF (TEST.LT.98.0.OR.TEST2.GT.0.0) GO TO 280
      IYD=IY+EVET
      KR=KR+1
      IPT(KR)=IND
      IF (METH.EQ.2) GO TO 230
      PART(3,IND)=CNODE+CONC(IX,IYD)*F2
      GO TO 240
  230 PART(3,IND)=2.0*C1*CONC(IX,IYD)/(C1+CONC(IX,IYD))
  240 IF (C1-CONC(IX,IYD)) 250,260,270
  250 RP(KR)=CONC(IX,IYD)-PART(3,IND)
      RN(KR)=C1-PART(3,IND)
      GO TO 280
  260 RP(KR)=0.0
      RN(KR)=0.0
      GO TO 280
  270 RP(KR)=C1-PART(3,IND)
      RN(KR)=CONC(IX,IYD)-PART(3,IND)
  280 IND=IND+1
C
  290 IF (TEST.LT.98.0.OR.TEST2.GT.0.0) GO TO 410
      SUMPT=0.0
C        ---COMPUTE CONC. GRADIENT WITHIN CELL---
      DO 300 KPT=1,NCHK
      IK=IPT(KPT)
  300 SUMPT=PART(3,IK)+SUMPT
      CBAR=SUMPT/NCHK
C        ---CHECK MASS BALANCE WITHIN CELL AND ADJUST PT. CONCS.---
      SUMPT=0.0
      IF (CBAR-C1) 310,410,330
  310 CRCT=1.0-(CBAR/C1)
      IF (METH.EQ.1) CRCT=CBAR/C1
      DO 320 KPT=1,NCHK
      IK=IPT(KPT)
      PART(3,IK)=PART(3,IK)+RP(KPT)*CRCT
  320 SUMPT=SUMPT+PART(3,IK)
      CBARN=SUMPT/NCHK
      GO TO 350
  330 CRCT=1.0-(C1/CBAR)
      IF (METH.EQ.1) CRCT=C1/CBAR
      DO 340 KPT=1,NCHK
      IK=IPT(KPT)
      PART(3,IK)=PART(3,IK)+RN(KPT)*CRCT
  340 SUMPT=SUMPT+PART(3,IK)
      CBARN=SUMPT/NCHK
  350 IF (CBARN.EQ.C1) GO TO 410
C         ---CORRECT FOR OVERCOMPENSATION---
      CRCT=C1/CBARN
      DO 380 KPT=1,NCHK
      IK=IPT(KPT)
      PART(3,IK)=PART(3,IK)*CRCT
C         ---CHECK CONSTRAINTS---
      IF (PART(3,IK)-C1) 360,380,370
  360 CLIM=C1-RP(KPT)+RN(KPT)
      IF (PART(3,IK).LT.CLIM) GO TO 390
      GO TO 380
  370 CLIM=C1+RP(KPT)-RN(KPT)
      IF (PART(3,IK).GT.CLIM) GO TO 390
  380 CONTINUE
      GO TO 410
  390 TEST2=1.0
      DO 400 KPT=1,NCHK
      IK=IPT(KPT)
  400 PART(3,IK)=C1
  410 CONTINUE
      NP=IND
      IF (INT.EQ.0) CALL CHMOT
C     ************************************************************
      RETURN
C     ************************************************************
      END
```

```
**** TSO FOREGROUND HARDCOPY ****
DSNAME=U11236C.KONIMOD.CNTL                         (VELO    )

C  USE META COMMANDS (BELOW) WHEN COMPILED ON MICROCOMPUTER
C  $NOFLOATCALLS
C  $STORAGE:2
      SUBROUTINE VELO                                                     E  10
      CHARACTER*8 TITLE                                                   E  11
      REAL*8 TMRX,VPRM,HI,HR,HC,HK,WT,REC,RECH,TIM,AOPT                   E  30
      REAL*8 DXINV,DYINV,ARINV,PORINV                                     E  35
      REAL*8 XDEL,YDEL,S,AREA,SUMT,RHO,PARAM,TEST,TOL,PINT,HMIN,PYR       E  40
      REAL*8 RATE,SLEAK,DIV                                               E  50
      REAL*8 HJ                                                           E  55
      INTEGER FCON                                                        E  56
      COMMON /PRMI/ NTIM,NPMP,NPNT,NITP,N,NX,NY,NP,NREC,INT,NNX,NNY,NUMO  E  60
     1BS,NMOV,IMOV,NPMAX,ITMAX,NZCRIT,IPRNT,NPTPND,NPNTMV,NPNTVL,NPNTD,N  E  70
     2PNCHV,NPDELC,ICHK,FCON,IHEAD,ISOLV                                  E  82
      COMMON /PRMC/ NODEID(20,20),NPCELL(20,20),NPOLD(20,20),LIMBO(500),  E  85
     1IXOBS(5),IYOBS(5)                                                   E  86
     2,NDECAY,NSORB                                                       USNRC
      COMMON /HEDA/ THCK(20,20),PERM(20,20),TMWL(5,50),TMOBS(50),ANFCTR   E 110
     1,THICK(20,20)                                                       E 111
      COMMON /HEDB/ TMRX(20,20,2),VPRM(20,20),HI(20,20),HR(20,20),HC(20,  E 120
     120),HK(20,20),WT(20,20),REC(20,20),RECH(20,20),TIM(100),AOPT(20),T  E 130
     2ITLE(10),XDEL,YDEL,S,AREA,SUMT,RHO,PARAM,TEST,TOL,PINT,HMIN,PYR     E 140
     3,HJ(20,20)                                                          E 145
      COMMON /XINV/ DXINV,DYINV,ARINV,PORINV                              E 150
      COMMON /CHMA/ PART(3,3200),CONC(20,20),TMCN(5,50),VX(20,20),VY(20,  E 160
     120),CONINT(20,20),CNRECH(20,20),POROS,SUMTCH,BETA,TIMV,STORM,STORM  E 170
     2I,CMSIN,CMSOUT,FLMIN,FLMOT,SUMIO,CELDIS,DLTRAT,CSTORM               E 180
     3,DCYLAM,BLKDEN,SRBRAT,SRBSAT,SRBALF,VOLDCY,VOLSRB,SRBDCY            USNRC
      COMMON /CHMC/ SUMC(20,20),VXBDY(20,20),VYBDY(20,20)                 E 190
      COMMON /DIFUS/ DISP(20,20,4)                                        E 200
C     ***************************************************************     E 210
C     ---COMPUTE VELOCITIES AND STORE---                                  E 220
      VMAX=1.0E-10                                                        E 230
      VMAY=1.0E-10                                                        E 240
      VMXBD=1.0E-10                                                       E 250
      VMYBD=1.0E-10                                                       E 260
      TMV = 1.0E5*TIM(N)                                                  E 275
      LIM=0                                                               E 280
      MAXX = 0                                                            E 284
      MAXY = 0                                                            E 285
C                                                                         E 290
      DO 20 IX=1,NX                                                       E 300
      DO 20 IY=1,NY                                                       E 310
      DO 10 IZ=1,4                                                        E 320
   10 DISP(IX,IY,IZ)=0.0                                                  E 330
C                                                                         E 340
      IF (THCK(IX,IY).EQ.0.0) GO TO 20                                    E 350
      DIST = 0.0                                                          USNRC
      IF (NSORB.LT.1) GO TO 6                                             USNRC
      IF (NSORB.GT.1) GO TO 3                                             USNRC
C***  ******************LINEAR SORBTION***************                    USNRC
      DIST = SRBRAT*BLKDEN                                                USNRC
      GO TO 6                                                             USNRC
    3 IF (NSORB.GT.2) GO TO 4                                             USNRC
C***  ******************LANGMUIR SORBTION************                     USNRC
      DIST = BLKDEN*SRBRAT*SRBSAT/(1.0+SRBRAT*CONC(IX,IY))**2.0           USNRC
      GO TO 6                                                             USNRC
    4 IF (SRBALF.EQ.0.0) GO TO 6                                          USNRC
C***  ******************FREUNDLICH SORBTION***********                    USNRC
      LOGCON = -23.0                                                      USNRC
      IF (CONC(IX,IY).GT.1.0E-10) LOGCON = ALOG(CONC(IX,IY))              USNRC
    5 SRBEXP = (SRBALF-1.0)*LOGCON                                        USNRC
```

```
      IF (SRBEXP.GT.23.0) SRBEXP = 23.0                                 USNRC
      DIST = BLKDEN*SRBALF*SRBRAT*EXP(SRBEXP)                           USNRC
    6 RETARD = 1.0/(1.0+DIST)                                           USNRC
      RATE=REC(IX,IY)/AREA                                              E 360
      SLEAK=(HK(IX,IY)-WT(IX,IY))*VPRM(IX,IY)                           E 370
      DIV=RATE+SLEAK+RECH(IX,IY)                                        E 380
C                                                                       E 390
C        ---VELOCITIES AT NODES---                                      E 400
C           ---X-DIRECTION---                                           E 410
      DHX=HK(IX-1,IY)-HK(IX+1,IY)                                       E 421
      IF (THCK(IX-1,IY).EQ.0.0) DHX=HK(IX,IY)-HK(IX+1,IY)               E 431
      IF (THCK(IX+1,IY).EQ.0.0) DHX=HK(IX-1,IY)-HK(IX,IY)               E 441
      IF (THCK(IX-1,IY).EQ.0.0.AND.THCK(IX+1,IY).EQ.0.0) DHX=0.0        E 451
      GRDX=DHX*DXINV*0.50                                               E 455
      VX(IX,IY)=PERM(IX,IY)*GRDX*PORINV                                 E 460
     1                                  *RETARD                         USNRC
      ABVX=ABS(VX(IX,IY))                                               E 470
      IF (ABVX.GT.VMAX) VMAX=ABVX                                       E 480
C           ---Y-DIRECTION---                                           E 490
      DHY=HK(IX,IY-1)-HK(IX,IY+1)                                       E 501
      IF (THCK(IX,IY-1).EQ.0.0) DHY=HK(IX,IY)-HK(IX,IY+1)               E 511
      IF (THCK(IX,IY+1).EQ.0.0) DHY=HK(IX,IY-1)-HK(IX,IY)               E 521
      IF (THCK(IX,IY-1).EQ.0.0.AND.THCK(IX,IY+1).EQ.0.0) DHY=0.0        E 531
      GRDY=DHY*DYINV*0.50                                               E 535
      VY(IX,IY)=PERM(IX,IY)*GRDY*PORINV*ANFCTR                          E 540
     1                                         *RETARD                  USNRC
      ABVY=ABS(VY(IX,IY))                                               E 550
      IF (ABVY.GT.VMAY) VMAY=ABVY                                       E 560
C                                                                       E 570
C        ---VELOCITIES AT CELL BOUNDARIES---                            E 580
      GRDX=(HK(IX,IY)-HK(IX+1,IY))*DXINV                                E 590
      PERMX=2.0*PERM(IX,IY)*PERM(IX+1,IY)/(PERM(IX,IY)+PERM(IX+1,IY))   E 600
      VXBDY(IX,IY)=PERMX*GRDX*PORINV                                    E 610
     1                               *RETARD                            USNRC
      GRDY=(HK(IX,IY)-HK(IX,IY+1))*DYINV                                E 620
      PERMY=2.0*PERM(IX,IY)*PERM(IX,IY+1)/(PERM(IX,IY)+PERM(IX,IY+1))   E 630
      VYBDY(IX,IY)=PERMY*GRDY*PORINV*ANFCTR                             E 640
     1                                      *RETARD                     USNRC
      ABVX=ABS(VXBDY(IX,IY))                                            E 650
      ABVY=ABS(VYBDY(IX,IY))                                            E 660
      IF (ABVX.GT.VMXBD) VMXBD=ABVX                                     E 670
      IF (ABVY.GT.VMYBD) VMYBD=ABVY                                     E 680
C                                                                       E 690
      IF (DIV.GE.0.0) GO TO 20                                          E 700
      TDIV=(POROS*THCK(IX,IY))/DABS(DIV)                                E 710
      IF (TDIV.GE.TMV) GO TO 20                                         E 722
      TMV = TDIV                                                        E 724
      MAXX = IX                                                         E 725
      MAXY = IY                                                         E 726
   20 CONTINUE                                                          E 730
C     *****************************************************************  E 740
C     ---PRINT VELOCITIES---                                            E 750
      IF (NPNTVL.EQ.0) GO TO 80                                         E 760
      IF (NPNTVL.EQ.2) GO TO 30                                         E 770
      IF (NPNTVL.EQ.1.AND.N.EQ.1) GO TO 30                              E 780
      GO TO 80                                                          E 790
   30 WRITE (6,320)                                                     E 800
      WRITE (6,330)                                                     E 810
      DO 40 IY=1,NY                                                     E 820
   40 WRITE (6,350) (VX(IX,IY),IX=1,NX)                                 E 830
      WRITE (6,340)                                                     E 840
      DO 50 IY=1,NY                                                     E 850
   50 WRITE (6,350) (VXBDY(IX,IY),IX=1,NX)                              E 860
      WRITE (6,360)                                                     E 870
      WRITE (6,330)                                                     E 880
      DO 60 IY=1,NY                                                     E 890
   60 WRITE (6,350) (VY(IX,IY),IX=1,NX)
      WRITE (6,340)
      DO 70 IY=1,NY
   70 WRITE (6,350) (VYBDY(IX,IY),IX=1,NX)
C     ---PUNCH VELOCITIES---
   80 IF (NPNCHV.EQ.0) GO TO 110
      IF (NPNCHV.EQ.2) GO TO 90
      IF (NPNCHV.EQ.1.AND.N.EQ.1) GO TO 90
      GO TO 110
   90 WRITE (7,510) NX,NY,XDEL,YDEL,VMAX,VMAY
      DO 100 IY=1,NY
      WRITE (7,520) (VX(IX,IY),IX=1,NX)
  100 WRITE (7,520) (VY(IX,IY),IX=1,NX)
C     ***************************************************************
C     ---COMPUTE NEXT TIME STEP---
  110 WRITE (6,390)
      WRITE (6,400) VMAX,VMAY
      WRITE (6,410) VMXBD,VMYBD
      TDELX=CELDIS*XDEL/VMAX
      TDELY=CELDIS*YDEL/VMAY
      TDELXB=CELDIS*XDEL/VMXBD
      TDELYB=CELDIS*YDEL/VMYBD
      TIMV=AMIN1(TDELX,TDELY,TDELXB,TDELYB)
      IF (AMAX1(VMAX,VMAY,VMXBD,VMYBD).LE.1.0E-10) WRITE(6,570)
      WRITE (6,310) TMV,TIMV
      IF (TMV.LT.TIMV) GO TO 120
      LIM=-1
      GO TO 130
  120 TIMV=TMV
      LIM=1
  130 NTIMV=TIM(N)/TIMV
      NMOV=NTIMV+1
      WRITE (6,420) TIMV,NTIMV,NMOV
      TIMV=TIM(N)/NMOV
      WRITE (6,370) TIM(N)
      WRITE (6,380) TIMV
C
      IF (BETA.EQ.0.0) GO TO 200
C     ***************************************************************
C     ---COMPUTE DISPERSION COEFFICIENTS---
      ALPHA=BETA
      ALNG=ALPHA
      TRAN=DLTRAT*ALPHA
      XX2=XDEL*XDEL
      YY2=YDEL*YDEL
      XY2=4.0*XDEL*YDEL
      DO 150 IX=2,NNX
      DO 150 IY=2,NNY
      IF (THCK(IX,IY).EQ.0.0) GO TO 150
      VXE=VXBDY(IX,IY)
      VYS=VYBDY(IX,IY)
      IF (THCK(IX+1,IY).EQ.0.0) GO TO 140
C        ---FORWARD COEFFICIENTS: X-DIRECTION---
      VYE=(VYBDY(IX,IY-1)+VYBDY(IX+1,IY-1)+VYS+VYBDY(IX+1,IY))/4.0
      VXE2=VXE*VXE
      VYE2=VYE*VYE
      VMGE=SQRT(VXE2+VYE2)
      IF (VMGE.LT.1.0E-20) GO TO 140
      DALN=ALNG*VMGE
      DTRN=TRAN*VMGE
      VMGE2=VMGE*VMGE
C           ---XX COEFFICIENT---
      DISP(IX,IY,1)=(DALN*VXE2+DTRN*VYE2)/(VMGE2*XX2)
C           ---XY COEFFICIENT---
      DISP(IX,IY,3)=(DALN-DTRN)*VXE*VYE/(VMGE2*XY2)
C        ---FORWARD COEFFICIENTS: Y-DIRECTION---
```

```
  140 IF (THCK(IX,IY+1).EQ.0.0) GO TO 150
      VXS=(VXBDY(IX-1,IY)+VXE+VXBDY(IX-1,IY+1)+VXBDY(IX,IY+1))/4.0
      VYS2=VYS*VYS
      VXS2=VXS*VXS
      VMGS=SQRT(VXS2+VYS2)
      IF (VMGS.LT.1.0E-20) GO TO 150
      DALN=ALNG*VMGS
      DTRN=TRAN*VMGS
      VMGS2=VMGS*VMGS
C           ---YY COEFFICIENT---
      DISP(IX,IY,2)=(DALN*VYS2+DTRN*VXS2)/(VMGS2*YY2)
C           ---YX COEFFICIENT---
      DISP(IX,IY,4)=(DALN-DTRN)*VXS*VYS/(VMGS2*XY2)
  150 CONTINUE
C     ****************************************************************
C     ---ADJUST CROSS-PRODUCT TERMS FOR ZERO THICKNESS---
      DO 160 IX=2,NNX
      DO 160 IY=2,NNY
      IF (THCK(IX,IY+1).EQ.0.0.OR.THCK(IX+1,IY+1).EQ.0.0.OR.THCK(IX,IY-
     11).EQ.0.0.OR.THCK(IX+1,IY-1).EQ.0.0) DISP(IX,IY,3)=0.0
      IF (THCK(IX+1,IY).EQ.0.0.OR.THCK(IX+1,IY+1).EQ.0.0.OR.THCK(IX-1,IY
     1).EQ.0.0.OR.THCK(IX-1,IY+1).EQ.0.0) DISP(IX,IY,4)=0.0
  160 CONTINUE
C     ****************************************************************
C     ---CHECK FOR STABILITY OF EXPLICIT METHOD---
      TIMDIS=0.0
      DO 170 IX=2,NNX
      DO 170 IY=2,NNY
      TDCO=DISP(IX,IY,1)+DISP(IX,IY,2)
  170 IF (TDCO.GT.TIMDIS) TIMDIS=TDCO
      TIMDC=0.5/TIMDIS
      WRITE (6,440) TIMDC
      NTIMD=TIM(N)/TIMDC
      NDISP=NTIMD+1
      IF (NDISP.LE.NMOV) GO TO 180
      NMOV=NDISP
      TIMV=TIM(N)/NMOV
      LIM=0
  180 WRITE (6,430) TIMV,NTIMD,NMOV
C     ****************************************************************
C     ---ADJUST DISP. EQUATION COEFFICIENTS FOR SATURATED THICKNESS---
      DO 190 IX=2,NNX
      DO 190 IY=2,NNY
      IF (THCK(IX,IY).EQ.0.0) GO TO 190
      BAVX=2.0*THCK(IX,IY)*THCK(IX+1,IY)/(THCK(IX,IY)+THCK(IX+1,IY))
      BAVY=2.0*THCK(IX,IY)*THCK(IX,IY+1)/(THCK(IX,IY)+THCK(IX,IY+1))
      DISP(IX,IY,1)=DISP(IX,IY,1)*BAVX
      DISP(IX,IY,2)=DISP(IX,IY,2)*BAVY
      DISP(IX,IY,3)=DISP(IX,IY,3)*BAVX
      DISP(IX,IY,4)=DISP(IX,IY,4)*BAVY
  190 CONTINUE
C     ****************************************************************
  200 IF (NMOV.LT.2) GO TO 235
      IF (LIM) 210,220,230
  210 WRITE (6,530)
      GO TO 240
  220 WRITE (6,540)
      GO TO 240
  230 WRITE (6,550)
      WRITE (6,560) MAXX,MAXY
      GO TO 240
  235 WRITE (6,580)
C     ****************************************************************
C     ---PRINT DISPERSION EQUATION COEFFICIENTS---
  240 IF (NPNTD.EQ.0) GO TO 300
      IF (NPNTD.EQ.2) GO TO 250
      IF (NPNTD.EQ.1.AND.N.EQ.1) GO TO 250
      GO TO 300
  250 WRITE (6,450)
      WRITE (6,460)
      DO 260 IY=1,NY
  260 WRITE (6,500) (DISP(IX,IY,1),IX=1,NX)
      WRITE (6,470)
      DO 270 IY=1,NY
  270 WRITE (6,500) (DISP(IX,IY,2),IX=1,NX)
      WRITE (6,480)
      DO 280 IY=1,NY
  280 WRITE (6,500) (DISP(IX,IY,3),IX=1,NX)
      WRITE (6,490)
      DO 290 IY=1,NY
  290 WRITE (6,500) (DISP(IX,IY,4),IX=1,NX)
C     *********************************************************
  300 RETURN
C     *********************************************************
C
C
C
  310 FORMAT (1H ,19H TMV (MAX. INJ.) = ,G12.5/20H  TIMV (CELDIS)   = ,
     11P1E12.5)
  320 FORMAT (1H1,12HX VELOCITIES)
  330 FORMAT (1H ,25X,8HAT NODES/)
  340 FORMAT (1H0,25X,13HON BOUNDARIES/)
  350 FORMAT (1H ,1P10E12.3)
  360 FORMAT (1H1,12HY VELOCITIES)
  370 FORMAT (3H   ,11HTIM (N)  = ,1P1E12.5)
  380 FORMAT (3H   ,11HTIMEVELO = ,1P1E12.5)
  390 FORMAT (1H1,10X,29HSTABILITY CRITERIA --- M.O.C.//)
  400 FORMAT (1H0,8H VMAX = ,1P1E9.2,5X,7HVMAY = ,1P1E9.2)
  410 FORMAT (1H ,8H VMXBD= ,1P1E9.2,5X,7HVMYBD= ,1P1E9.2)
  420 FORMAT (1H0,8H TIMV = ,1P1E9.2,5X,8HNTIMV = ,I5,5X,7HNMOV = ,I5/)
  430 FORMAT (1H0,8H TIMV = ,1P1E9.2,5X,8HNTIMD = ,I5,5X,7HNMOV = ,I5)
  440 FORMAT (3H   ,11HTIMEDISP = ,1P1E12.5)
  450 FORMAT (1H1,32HDISPERSION EQUATION COEFFICIENTS,10X,25H=(D-IJ)*(B)
     1/(GRID FACTOR))
  460 FORMAT (1H ,35X,14HXX COEFFICIENT/)
  470 FORMAT (1H ,35X,14HYY COEFFICIENT/)
  480 FORMAT (1H ,35X,14HXY COEFFICIENT/)
  490 FORMAT (1H ,35X,14HYX COEFFICIENT/)
  500 FORMAT (1H ,1P10E8.1)
  510 FORMAT (2I4,2F10.1,2F10.7)
  520 FORMAT (8F10.7)
  530 FORMAT (1H0,10X,42HTHE LIMITING STABILITY CRITERION IS CELDIS)
  540 FORMAT (1H0,10X,40HTHE LIMITING STABILITY CRITERION IS BETA)
  550 FORMAT (1H0,10X,58HTHE LIMITING STABILITY CRITERION IS MAXIMUM INJ
     1ECTION RATE)
  560 FORMAT (1H ,15X,35H MAX. INJECTION OCCURS IN CELL IX = ,I3,6H IY =
     1       ,I3)
  570 FORMAT (1H0,5X,47H*** WARNING ***  DECREASE CRITERIA IN E 230-260)
  580 FORMAT (1H0,10X,63H*TIME INCREMENT FOR SOLUTE TRANSPORT EQUALS TIM
     1E STEP FOR FLOW*)
      END
```

```
**** TSO FOREGROUND HARDCOPY ****
DSNAME=U11236C.KONIMOD.CNTL                          (MOVE     )
C  USE META COMMANDS (BELOW) WHEN COMPILED ON MICROCOMPUTER
C  $NOFLOATCALLS
C  $STORAGE:2
      SUBROUTINE MOVE                                                   F   10
      CHARACTER*8 TITLE                                                 F   11
      REAL*8 TMRX,VPRM,HI,HR,HC,HK,WT,REC,RECH,TIM,AOPT                 F   20
      REAL*8 XDEL,YDEL,S,AREA,SUMT,RHO,PARAM,TEST,TOL,PINT,HMIN,PYR     F   30
      REAL*8 DXINV,DYINV,ARINV,PORINV                                   F   32
      REAL*8 HJ                                                         F   33
      INTEGER  PTID                                                     F   35
      INTEGER  FCON                                                     F   36
      COMMON /PRMI/ NTIM,NPMP,NPNT,NITP,N,NX,NY,NP,NREC,INT,NNX,NNY,NUMO F   40
     1BS,NMOV,IMOV,NPMAX,ITMAX,NZCRIT,IPRNT,NPTPND,NPNTMV,NPNTVL,NPNTD,N F   50
     2PNCHV,NPDELC,ICHK,FCON,IHEAD,ISOLV                                F   62
      COMMON /PRMC/ NODEID(20,20),NPCELL(20,20),NPOLD(20,20),LIMBO(500), F   65
     1IXOBS(5),IYOBS(5)                                                 F   66
     2,NDECAY,NSORB                                                     USNRC
      COMMON /HEDA/ THCK(20,20),PERM(20,20),TMWL(5,50),TMOBS(50),ANFCTR F   90
     1,THICK(20,20)                                                     F   91
      COMMON /HEDB/ TMRX(20,20,2),VPRM(20,20),HI(20,20),HR(20,20),HC(20, F  100
     120),HK(20,20),WT(20,20),REC(20,20),RECH(20,20),TIM(100),AOPT(20),T F  110
     2ITLE(10),XDEL,YDEL,S,AREA,SUMT,RHO,PARAM,TEST,TOL,PINT,HMIN,PYR   F  120
     3,HJ(20,20)                                                        F  125
      COMMON /XINV/ DXINV,DYINV,ARINV,PORINV                            F  130
      COMMON /CHMA/ PART(3,3200),CONC(20,20),TMCN(5,50),VX(20,20),VY(20, F  140
     120),CONINT(20,20),CNRECH(20,20),POROS,SUMTCH,BETA,TIMV,STORM,STORM F  150
     2I,CMSIN,CMSOUT,FLMIN,FLMOT,SUMIO,CELDIS,DLTRAT,CSTORM             F  160
     3,DCYLAM,BLKDEN,SRBRAT,SRBSAT,SRBALF,VOLDCY,VOLSRB,SRBDCY          USNRC
      COMMON /CHMC/ SUMC(20,20),VXBDY(20,20),VYBDY(20,20)               F  170
      COMMON /CHMP/ PTID(3200)                                          F  175
C     ***************************************************************** F  190
      WRITE (6,680) NMOV                                                F  200
      SUMTCH=SUMT-TIM(N)                                                F  210
      F1=0.30                                                           F  212
      F2=1.0/3.0                                                        F  214
      IF (NPTPND.EQ.4) F1=0.25                                          F  216
      IF (NPTPND.EQ.9) F1=F2                                            F  218
      IF (NPTPND.EQ.8) F2=0.25                                          F  222
      CONST1=TIMV*DXINV                                                 F  250
      CONST2=TIMV*DYINV                                                 F  260
C     ---MOVE PARTICLES "NMOV" TIMES---                                 F  270
      DO 650 IMOV=1,NMOV                                                F  280
   10 NPTM=NP                                                           F  290
C          ---MOVE EACH PARTICLE---                                     F  300
      DO 590 IN=1,NP                                                    F  310
      IF (PART(1,IN).EQ.0.0) GO TO 590                                  F  320
      KFLAG=0                                                           F  330
C     ***************************************************************** F  340
C               ---COMPUTE OLD LOCATION---                              F  350
   20 XOLD=PART(1,IN)                                                   F  400
      IX=XOLD+0.5                                                       F  410
      IFLAG=1                                                           F  420
      IF (PART(2,IN).GE.0.0) GO TO 30                                   F  430
      IFLAG=-1                                                          F  440
      PART(2,IN)=-PART(2,IN)                                            F  450
   30 YOLD=PART(2,IN)                                                   F  460
      IY=YOLD+0.5                                                       F  470
      IF (THCK(IX,IY).EQ.0.0) GO TO 590                                 F  482
C     ***************************************************************** F  490
C               ---COMPUTE NEW LOCATION AND LOCATE CLOSEST NODE---      F  500
C               ---LOCATE NORTHWEST CORNER---                           F  510
      IVX=XOLD                                                          F  520
      IVY=YOLD
      IXE=IVX+1
      IYS=IVY+1
C     ***********************************************************
C        ---LOCATE QUADRANT, VEL. AT 4 CORNERS, CHECK FOR BOUNDARIES---
      CELDX=XOLD-IX
      CELDY=YOLD-IY
      ICD=9
      IF (CELDX.EQ.0.0.AND.CELDY.EQ.0.0) GO TO 280
      IF (CELDX.GE.0.0.OR.CELDY.GE.0.0) GO TO 70
C               ---PT. IN NW QUADRANT---
      VXNW=VXBDY(IVX,IVY)
      VXNE=VX(IXE,IVY)
      VXSW=VXBDY(IVX,IYS)
      VXSE=VX(IXE,IYS)
      VYNW=VYBDY(IVX,IVY)
      VYNE=VYBDY(IXE,IVY)
      VYSW=VY(IVX,IYS)
      VYSE=VY(IXE,IYS)
      ICD=1
      IF (THCK(IVX,IVY).EQ.0.0) GO TO 50
      IF (REC(IXE,IVY).EQ.0.0.AND.VPRM(IXE,IVY).LT.0.09) GO TO 40
      VXNE=VXNW
   40 IF (REC(IVX,IYS).EQ.0.0.AND.VPRM(IVX,IYS).LT.0.09) GO TO 50
      VYSW=VYNW
   50 IF (REC(IXE,IYS).EQ.0.0.AND.VPRM(IXE,IYS).LT.0.09) GO TO 270
      IF (THCK(IVX,IYS).EQ.0.0) GO TO 60
      IF (THCK(IXE+1,IYS).GT.0.0) VXSE=VXSW
   60 IF (THCK(IXE,IVY).EQ.0.0) GO TO 270
      IF (THCK(IXE,IYS+1).GT.0.0) VYSE=VYNE
      GO TO 270
C
   70 IF (CELDX.LE.0.0.OR.CELDY.GE.0.0) GO TO 130
C               ---PT. IN NE QUADRANT---
   80 VXNW=VX(IVX,IVY)
      VXNE=VXBDY(IVX,IVY)
      VXSW=VX(IVX,IYS)
      VXSE=VXBDY(IVX,IYS)
      VYNW=VYBDY(IVX,IVY)
      VYNE=VYBDY(IXE,IVY)
      VYSW=VY(IVX,IYS)
      VYSE=VY(IXE,IYS)
      ICD=2
      IF (CELDX.EQ.0.0) GO TO 120
      IF (THCK(IXE,IVY).EQ.0.0) GO TO 100
      IF (REC(IVX,IVY).EQ.0.0.AND.VPRM(IVX,IVY).LT.0.09) GO TO 90
      VXNW=VXNE
   90 IF (REC(IXE,IYS).EQ.0.0.AND.VPRM(IXE,IYS).LT.0.09) GO TO 100
      VYSE=VYNE
  100 IF (REC(IVX,IYS).EQ.0.0.AND.VPRM(IVX,IYS).LT.0.09) GO TO 270
      IF (THCK(IXE,IYS).EQ.0.0) GO TO 110
      IF (THCK(IVX-1,IYS).GT.0.0) VXSW=VXSE
  110 IF (THCK(IVX,IVY).EQ.0.0) GO TO 270
      IF (THCK(IVX,IYS+1).GT.0.0) VYSW=VYNW
      GO TO 270
  120 IF (REC(IVX,IYS).EQ.0.0.AND.VPRM(IVX,IYS).LE.0.09) GO TO 270
      IF (THCK(IVX,IVY).EQ.0.0) GO TO 270
      IF (THCK(IVX,IYS+1).GT.0.0) VYSW=VYNW
      GO TO 270
C
  130 IF (CELDY.LE.0.0.OR.CELDX.GE.0.0) GO TO 190
C               ---PT. IN SW QUADRANT---
  140 VXNW=VXBDY(IVX,IVY)
      VXNE=VX(IXE,IVY)
      VXSW=VXBDY(IVX,IYS)
      VXSE=VX(IXE,IYS)
      VYNW=VY(IVX,IVY)
      VYNE=VY(IXE,IVY)                                                  F1160
      VYSW=VYBDY(IVX,IVY)                                               F1170
      VYSE=VYBDY(IXE,IVY)                                               F1180
      ICD=3                                                             F1190
      IF (CELDY.EQ.0.0) GO TO 180                                       F1195
      IF (THCK(IVX,IYS).EQ.0.0) GO TO 160                               F1200
      IF (REC(IVX,IVY).EQ.0.0.AND.VPRM(IVX,IVY).LT.0.09) GO TO 150      F1210
      VYNW=VYSW                                                         F1220
  150 IF (REC(IXE,IYS).EQ.0.0.AND.VPRM(IXE,IYS).LT.0.09) GO TO 160      F1230
      VXSE=VXSW                                                         F1240
  160 IF (REC(IXE,IVY).EQ.0.0.AND.VPRM(IXE,IVY).LT.0.09) GO TO 270      F1250
      IF (THCK(IVX,IVY).EQ.0.0) GO TO 170                               F1260
      IF (THCK(IXE+1,IVY).GT.0.0) VXNE=VXNW                             F1270
  170 IF (THCK(IXE,IYS).EQ.0.0) GO TO 270                               F1282
      IF (THCK(IXE,IVY-1).GT.0.0) VYNE=VYSE                             F1290
      GO TO 270                                                         F1302
  180 IF (REC(IXE,IVY).EQ.0.0.AND.VPRM(IXE,IVY).LE.0.09) GO TO 270      F1310
      IF (THCK(IVX,IVY).EQ.0.0) GO TO 270                               F1320
      IF (THCK(IXE+1,IVY).GT.0.0) VXNE=VXNW                             F1330
      GO TO 270                                                         F1342
C                                                                       F1350
  190 IF (CELDY.LE.0.0.OR.CELDX.LE.0.0) GO TO 260                       F1360
C                ---PT. IN SE QUADRANT---                               F1370
  200 VXNW=VX(IVX,IVY)                                                  F1380
      VXNE=VXBDY(IVX,IVY)                                               F1390
      VXSW=VX(IVX,IYS)                                                  F1400
      VXSE=VXBDY(IVX,IYS)                                               F1410
      VYNW=VY(IVX,IVY)                                                  F1420
      VYNE=VY(IXE,IVY)                                                  F1430
      VYSW=VYBDY(IVX,IVY)                                               F1440
      VYSE=VYBDY(IXE,IVY)                                               F1450
      ICD=4                                                             F1460
      IF (CELDY.EQ.0.0) GO TO 240                                       F1465
      IF (CELDX.EQ.0.0) GO TO 250                                       F1470
      IF (THCK(IXE,IYS).EQ.0.0) GO TO 220                               F1480
      IF (REC(IXE,IVY).EQ.0.0.AND.VPRM(IXE,IVY).LT.0.09) GO TO 210      F1490
      VYNE=VYSE                                                         F1500
  210 IF (REC(IVX,IYS).EQ.0.0.AND.VPRM(IVX,IYS).LT.0.09) GO TO 220      F1510
      VXSW=VXSE                                                         F1520
  220 IF (REC(IVX,IVY).EQ.0.0.AND.VPRM(IVX,IVY).LT.0.09) GO TO 270      F1530
      IF (THCK(IXE,IVY).EQ.0.0) GO TO 230                               F1540
      IF (THCK(IVX-1,IVY).GT.0.0) VXNW=VXNE                             F1550
  230 IF (THCK(IVX,IYS).EQ.0.0) GO TO 270                               F1562
      IF (THCK(IVX,IVY-1).GT.0.0) VYNW=VYSW                             F1570
      GO TO 270                                                         F1582
  240 IF (REC(IVX,IVY).EQ.0.0.AND.VPRM(IVX,IVY).LE.0.09) GO TO 270      F1590
      IF (THCK(IXE,IVY).EQ.0.0) GO TO 270                               F1600
      IF (THCK(IVX-1,IVY).GT.0.0) VXNW=VXNE                             F1610
      GO TO 270                                                         F1622
  250 IF (REC(IVX,IVY).EQ.0.0.AND.VPRM(IVX,IVY).LE.0.09) GO TO 270      F1630
      IF (THCK(IVX,IYS).EQ.0.0) GO TO 270                               F1640
      IF (THCK(IVX,IVY-1).GT.0.0) VYNW=VYSW                             F1650
      GO TO 270                                                         F1662
C                                                                       F1670
  260 IF (CELDX.EQ.0.0.AND.CELDY.LT.0.0) GO TO 80                       F1680
      IF (CELDX.LT.0.0.AND.CELDY.EQ.0.0) GO TO 140                      F1690
      IF (CELDX.GT.0.0.AND.CELDY.EQ.0.0) GO TO 200                      F1700
      IF (CELDX.EQ.0.0.AND.CELDY.GT.0.0) GO TO 200                      F1710
      WRITE (6,690) IN,IX,IY                                            F1720
  270 CONTINUE                                                          F1730
C               --- CHECK FOR ADJACENT NO-FLOW BOUNDARIES ---           F1740
      GO TO (1270,1275,1280,1285,1290),ICD                              F1741A
      GO TO 1290                                                        F1741B
 1270 IF (THCK(IXE,IVY).EQ.0.0) GO TO 1272                              F1741C
      IF (THCK(IVX,IYS).EQ.0.0) GO TO 1273                              F1742A
                                                                        F1742B
      IF (THCK(IVX,IVY).EQ.0.0) GO TO 1274                              F1742C
      GO TO 1290                                                        F1742D
 1272 VXNE=VXSE                                                         F1742E
      IF (THCK(IVX,IYS).GT.0.0) GO TO 1274                              F1742F
 1273 VYSW=VYSE                                                         F1742G
 1274 VXNW=VXSW                                                         F1742H
      VYNW=VYNE                                                         F1742I
      GO TO 1290                                                        F1742J
 1275 IF (THCK(IVX,IVY).EQ.0.0) GO TO 1277                              F1744A
      IF (THCK(IXE,IYS).EQ.0.0) GO TO 1278                              F1744B
      IF (THCK(IXE,IVY).EQ.0.0) GO TO 1279                              F1744C
      GO TO 1290                                                        F1742D
 1277 VXNW=VXSW                                                         F1744E
      IF (THCK(IXE,IYS).GT.0.0) GO TO 1279                              F1744F
 1278 VYSE=VYSW                                                         F1744G
 1279 VXNE=VXSE                                                         F1744H
      VYNE=VYNW                                                         F1744I
      GO TO 1290                                                        F1744J
 1280 IF (THCK(IXE,IYS).EQ.0.0) GO TO 1282                              F1746A
      IF (THCK(IVX,IVY).EQ.0.0) GO TO 1283                              F1746B
      IF (THCK(IVX,IYS).EQ.0.0) GO TO 1284                              F1746C
      GO TO 1290                                                        F1746D
 1282 VXSE=VXNE                                                         F1746E
      IF (THCK(IVX,IVY).GT.0.0) GO TO 1284                              F1746F
 1283 VYNW=VYNE                                                         F1746G
 1284 VXSW=VXNW                                                         F1746H
      VYSW=VYSE                                                         F1746I
      GO TO 1290                                                        F1746J
 1285 IF (THCK(IVX,IYS).EQ.0.0) GO TO 1287                              F1748A
      IF (THCK(IXE,IVY).EQ.0.0) GO TO 1288                              F1748B
      IF (THCK(IXE,IYS).EQ.0.0) GO TO 1289                              F1748C
      GO TO 1290                                                        F1748D
 1287 VXSW=VXNW                                                         F1748E
      IF (THCK(IXE,IVY).GT.0.0) GO TO 1289                              F1748F
 1288 VYNE=VYNW                                                         F1748G
 1289 VYSE=VYSW                                                         F1748H
      VXSE=VXNE                                                         F1748I
 1290 CONTINUE                                                          F1749A
C     ****************************************************************  F1750
C        ---BILINEAR INTERPOLATION---                                   F1760
      CELXD=XOLD-IVX                                                    F1770
      CELDXH=AMOD(CELXD,0.5)                                            F1780
      CELDX=CELDXH*2.0                                                  F1790
      CELDY=YOLD-IVY                                                    F1800
C     ****************************************************************  F1810
C           ---X VELOCITY---                                            F1820
      VXN=VXNW*(1.0-CELDX)+VXNE*CELDX                                   F1830
      VXS=VXSW*(1.0-CELDX)+VXSE*CELDX                                   F1850
      XVEL=VXN*(1.0-CELDY)+VXS*CELDY                                    F1870
C           ---Y VELOCITY---                                            F1900
      CELDYH=AMOD(CELDY,0.5)                                            F1910
      CELYD=CELDYH*2.0                                                  F1921
      VYW=VYNW*(1.0-CELYD)+VYSW*CELYD                                   F1931
      VYE=VYNE*(1.0-CELYD)+VYSE*CELYD                                   F1951
      YVEL=VYW*(1.0-CELXD)+VYE*CELXD                                    F1970
C                                                                       F2000
      GO TO 290                                                         F2010
  280 XVEL=VX(IX,IY)                                                    F2020
      YVEL=VY(IX,IY)                                                    F2030
  290 DISTX=XVEL*CONST1                                                 F2040
      DISTY=YVEL*CONST2                                                 F2050
C     ****************************************************************  F2060
C        ---BOUNDARY CONDITIONS---                                      F2070
      TEMPX=XOLD+DISTX                                                  F2080
      TEMPY=YOLD+DISTY                                                  F2090
      INX=TEMPX+0.5                                                     F2100
      INY=TEMPY+0.5
      IF (THCK(INX,INY).GT.0.0) GO TO 330                                F2110
C     ******************************************************************   F2120
C           ---X BOUNDARY---                                              F2130
      IF (THCK(INX,IY).EQ.0.0) GO TO 300                                 F2140
      PART(1,IN)=TEMPX                                                   F2150
      GO TO 310                                                          F2160
  300 BEYON=TEMPX-IX                                                     F2170
      IF (BEYON.LT.0.0) BEYON=BEYON+0.5                                  F2180
      IF (BEYON.GT.0.0) BEYON=BEYON-0.5                                  F2190
      PART(1,IN)=TEMPX-2.0*BEYON                                         F2200
      INX=PART(1,IN)+0.5                                                 F2210
      TEMPX=PART(1,IN)                                                   F2220
C     ******************************************************************   F2230
C           ---Y BOUNDARY---                                              F2240
  310 IF (THCK(INX,INY).EQ.0.0) GO TO 320                                F2250
      PART(2,IN)=TEMPY                                                   F2260
      GO TO 340                                                          F2270
C     ******************************************************************   F2280
  320 BEYON=TEMPY-IY                                                     F2290
      IF (BEYON.LT.0.0) BEYON=BEYON+0.5                                  F2300
      IF (BEYON.GT.0.0) BEYON=BEYON-0.5                                  F2310
      PART(2,IN)=TEMPY-2.0*BEYON                                         F2320
      INY=PART(2,IN)+0.5                                                 F2330
      TEMPY=PART(2,IN)                                                   F2340
      GO TO 340                                                          F2350
  330 PART(1,IN)=TEMPX                                                   F2360
      PART(2,IN)=TEMPY                                                   F2370
  340 CONTINUE                                                           F2380
C     ******************************************************************   F2390
C           ---SUM CONCENTRATIONS AND COUNT PARTICLES---                  F2400
      SUMC(INX,INY)=SUMC(INX,INY)+PART(3,IN)                             F2410
      NPCELL(INX,INY)=NPCELL(INX,INY)+1                                  F2420
C     ******************************************************************   F2430
C           ---CHECK FOR CHANGE IN CELL LOCATION---                       F2440
      IF (IX.EQ.INX.AND.IY.EQ.INY) GO TO 580                             F2450
C             ---CHECK FOR CONST.-HEAD BDY. OR SOURCE AT OLD LOCATION---  F2460
      IF (REC(IX,IY).LT.0.0) GO TO 350                                   F2470
      IF (REC(IX,IY).GT.0.0) GO TO 360                                   F2480
      IF (VPRM(IX,IY).LT.0.09) GO TO 540                                 F2490
      IF (WT(IX,IY).GT.HK(IX,IY)) GO TO 350                              F2500
      IF (WT(IX,IY).LT.HK(IX,IY)) GO TO 360                              F2510
      GO TO 540                                                          F2520
C     ******************************************************************   F2530
C             ---CREATE NEW PARTICLES AT BOUNDARIES---                    F2540
  350 IF (IFLAG.GT.0) GO TO 550                                          F2550
      KFLAG=1                                                            F2560
  360 DO 370 IL=1,500                                                    F2570
      IF (LIMBO(IL).EQ.0) GO TO 370                                      F2580
      IP=LIMBO(IL)                                                       F2590
      IF (IP.LT.IN) GO TO 380                                            F2600
  370 CONTINUE                                                           F2610
C     ******************************************************************   F2620
C             ---GENERATE NEW PARTICLE---                                 F2630
      IF (NPTM.EQ.NPMAX) GO TO 600                                       F2640
      NPTM=NPTM+1                                                        F2650
      IP=NPTM                                                            F2660
      GO TO 390                                                          F2670
  380 LIMBO(IL)=0                                                        F2680
C                                                                        F2690
  390 IF (KFLAG.EQ.0) GO TO 398                                          F2700
      ITEM=PTID(IN)                                                      F2705
      GO TO 399                                                          F2845
  398 SUMC(IX,IY)=SUMC(IX,IY)+CONC(IX,IY)                                F2855
      NPCELL(IX,IY)=NPCELL(IX,IY)+1                                      F2865
      IF (NPOLD(IX,IY).GT.0) NPOLD(IX,IY)=NPOLD(IX,IY)-1                 F2875
                                                                         F2885
      IF (IFLAG.GT.0) GO TO 441                                         F2895
      IF (KFLAG.EQ.0) GO TO 441                                         F2899
  399 GO TO (401,411,421,431,441,451,461,471,481),ITEM                  F2905
      GO TO 441                                                         F2915
  401 PART(1,IP)=IX-F1                                                  F2925
      PART(2,IP)=IY-F1                                                  F2935
      PTID(IP)=1                                                        F2935
      GO TO 530                                                         F2955
  411 PART(1,IP)=IX-F1                                                  F2965
      PART(2,IP)=IY+F1                                                  F2975
      PTID(IP)=2                                                        F2985
      GO TO 530                                                         F2995
  421 PART(1,IP)=IX+F1                                                  F3005
      PART(2,IP)=IY-F1                                                  F3015
      PTID(IP)=3                                                        F3025
      GO TO 530                                                         F3035
  431 PART(1,IP)=IX+F1                                                  F3045
      PART(2,IP)=IY+F1                                                  F3055
      PTID(IP)=4                                                        F3065
      GO TO 530                                                         F3075
  441 PART(1,IP)=IX                                                     F3085
      PART(2,IP)=IY                                                     F3095
      PTID(IP)=5                                                        F3105
      GO TO 530                                                         F3115
  451 PART(1,IP)=IX-F2                                                  F3125
      PART(2,IP)=IY                                                     F3135
      PTID(IP)=6                                                        F3145
      GO TO 530                                                         F3155
  461 PART(1,IP)=IX                                                     F3165
      PART(2,IP)=IY-F2                                                  F3175
      PTID(IP)=7                                                        F3185
      GO TO 530                                                         F3195
  471 PART(1,IP)=IX+F2                                                  F3205
      PART(2,IP)=IY                                                     F3215
      PTID(IP)=8                                                        F3225
      GO TO 530                                                         F3235
  481 PART(1,IP)=IX                                                     F3245
      PART(2,IP)=IY+F2                                                  F3255
      PTID(IP)=9                                                        F3265
C                                                                       F3510
  530 PART(2,IP)=-PART(2,IP)                                            F3520
      PART(3,IP)=CONC(IX,IY)                                            F3530
C     ***************************************************************** F3550
C             ---CHECK FOR DISCHARGE BOUNDARY AT NEW LOCATION---        F3560
  540 IFLAG=1.0                                                         F3570
  550 IF (VPRM(INX,INY).GT.0.09.AND.WT(INX,INY).LT.HK(INX,INY)) GO TO 56F3580
     10                                                                 F3590
      IF (REC(INX,INY).GT.0.0) GO TO 560                                F3600
      GO TO 590                                                         F3610
C     ***************************************************************** F3620
C             ---PUT PT. IN LIMBO IF PT. DENSITY NOT INCREASED---       F3625
  560 IF (NPOLD(INX,INY).LE.0) GO TO 590                                F3635
      PART(1,IN)=0.0                                                    F3645
      PART(2,IN)=0.0                                                    F3650
      PART(3,IN)=0.0                                                    F3660
      SUMC(INX,INY)=SUMC(INX,INY)-CONC(INX,INY)                         F3662
      NPCELL(INX,INY)=NPCELL(INX,INY)-1                                 F3664
      NPOLD(INX,INY)=NPOLD(INX,INY)-1                                   F3666
      DO 570 ID=1,500                                                   F3670
      IF (LIMBO(ID).GT.0) GO TO 570                                     F3680
      LIMBO(ID)=IN                                                      F3690
      GO TO 590                                                         F3700
  570 CONTINUE                                                          F3710
C                                                                       F3720
  580 IF (IFLAG.LT.0) PART(2,IN)=-TEMPY                                 F3730
  590 CONTINUE                                                          F3750
```

```
C     ---END OF LOOP---                                                 F3760
C     ************************************************************     F3770
      GO TO 620                                                         F3780
C         ---RESTART MOVE IF PT. LIMIT EXCEEDED---                      F3790
  600 WRITE (6,700) IMOV,IN                                             F3800
      TEST=100.0                                                        F3810
      CALL GENPT                                                        F3820
      DO 610 IX=1,NX                                                    F3830
      DO 610 IY=1,NY                                                    F3840
      SUMC(IX,IY)=0.0                                                   F3850
  610 NPCELL(IX,IY)=0                                                   F3860
      TEST=0.0                                                          F3870
      GO TO 10                                                          F3880
C     ************************************************************     F3890
  620 SUMTCH=SUMTCH+TIMV                                                F3900
C         ---ADJUST NUMBER OF PARTICLES---                              F3910
      NP=NPTM                                                           F3920
      WRITE (6,670) NP,IMOV                                             F3930
C     ************************************************************     F3940
      CALL CNCON                                                        F3950
C     ************************************************************     F3960
C         ---STORE OBS. WELL DATA FOR STEADY FLOW PROBLEMS---           F3970
      IF (S.GT.0.0) GO TO 640                                           F3980
      IF (NUMOBS.LE.0) GO TO 640                                        F3990
      J=MOD(IMOV,50)                                                    F4000
      IF (J.EQ.0) J=50                                                  F4010
      TMOBS(J)=SUMTCH                                                   F4020
      DO 630 I=1,NUMOBS                                                 F4030
      TMWL(I,J)=HK(IXOBS(I),IYOBS(I))                                   F4040
  630 TMCN(I,J)=CONC(IXOBS(I),IYOBS(I))                                 F4050
C         ---PRINT CHEMICAL OUTPUT---                                   F4060
      IF (MOD(IMOV,50).EQ.0) IPRNT = 1                                  F4065
  640 IF (IMOV.GE.NMOV) GO TO 660                                       F4070
      IF (MOD(IMOV,NPNTMV).EQ.0) IPRNT = -1                             F4082
  650 IF (IPRNT.NE.0) CALL CHMOT                                        F4085
C     ************************************************************     F4090
  660 RETURN                                                            F4100
C     ************************************************************     F4110
C                                                                       F4120
C                                                                       F4130
C                                                                       F4140
  670 FORMAT (1H0,2X,2HNP,7X,2H= ,8X,I4,10X,11HIMOV      = ,8X,I4)      F4150
  680 FORMAT (1H0,10X,61HNO. OF PARTICLE MOVES REQUIRED TO COMPLETE THIS F4160
     1 TIME STEP  = ,I4//)                                              F4170
  690 FORMAT (1H0,5X,53H*** WARNING ***      QUADRANT NOT LOCATED FOR PT. F4180
     1 NO. ,I5,11H , IN CELL ,2I4)                                      F4190
  700 FORMAT (1H0,5X,17H ***    NOTE    ***,10X,23HNPTM.EQ.NPMAX --- IMOV= F4200
     1,I4,5X,8HPT. NO.=,I4,5X,10HCALL GENPT/)                           F4210
      END                                                               F4220-
```

```
**** TSO FOREGROUND HARDCOPY ****
DSNAME=U11236C.KONIMOD.CNTL                              (CNCON   )

C  USE META COMMANDS (BELOW) WHEN COMPILED ON MICROCOMPUTER
C  $NOFLOATCALLS
C  $STORAGE:2
      SUBROUTINE CNCON                                                  G  10
      CHARACTER*8 TITLE                                                 G  11
      REAL*8 TMRX,VPRM,HI,HR,HC,HK,WT,REC,RECH,TIM,AOPT                 G  20
      REAL*8 XDEL,YDEL,S,AREA,SUMT,RHO,PARAM,TEST,TOL,PINT,HMIN,PYR     G  30
      REAL*8 DXINV,DYINV,ARINV,PORINV                                   G  35
      REAL*8 FLW                                                        G  40
      REAL*8 HJ                                                         G  45
      INTEGER FCON                                                      G  46
      COMMON /PRMI/ NTIM,NPMP,NPNT,NITP,N,NX,NY,NP,NREC,INT,NNX,NNY,NUMO G  50
     1BS,NMOV,IMOV,NPMAX,ITMAX,NZCRIT,IPRNT,NPTPND,NPNTMV,NPNTVL,NPNTD,N G  60
     2PNCHV,NPDELC,ICHK,FCON,IHEAD,ISOLV                                G  72
      COMMON /PRMC/ NODEID(20,20),NPCELL(20,20),NPOLD(20,20),LIMBO(500), G  75
     1IXOBS(5),IYOBS(5)                                                 G  76
     2,NDECAY,NSORB                                                     USNRC
      COMMON /HEDA/ THCK(20,20),PERM(20,20),TMWL(5,50),TMOBS(50),ANFCTR  G 100
     1,THICK(20,20)                                                     G 101
      COMMON /HEDB/ TMRX(20,20,2),VPRM(20,20),HI(20,20),HR(20,20),HC(20, G 110
     120),HK(20,20),WT(20,20),REC(20,20),RECH(20,20),TIM(100),AOPT(20),T G 120
     2ITLE(10),XDEL,YDEL,S,AREA,SUMT,RHO,PARAM,TEST,TOL,PINT,HMIN,PYR    G 130
     3,HJ(20,20)                                                        G 135
      COMMON /XINV/ DXINV,DYINV,ARINV,PORINV                            G 140
      COMMON /CHMA/ PART(3,3200),CONC(20,20),TMCN(5,50),VX(20,20),VY(20, G 150
     120),CONINT(20,20),CNRECH(20,20),POROS,SUMTCH,BETA,TIMV,STORM,STORM G 160
     2I,CMSIN,CMSOUT,FLMIN,FLMOT,SUMIO,CELDIS,DLTRAT,CSTORM             G 170
     3,DCYLAM,BLKDEN,SRBRAT,SRBSAT,SRBALF,VOLDCY,VOLSRB,SRBDCY          USNRC
      COMMON /DIFUS/ DISP(20,20,4)                                      G 180
      COMMON /CHMC/ SUMC(20,20),VXBDY(20,20),VYBDY(20,20)               G 190
      DIMENSION CNCNC(20,20), CNOLD(20,20)                              G 200
C     ************************************************************      G 210
      ITEST=0                                                           G 220
      NZERO=0                                                           USNRC
      STORM=0.0                                                         USNRC
      DO 10 IX=1,NX                                                     G 230
      DO 10 IY=1,NY                                                     G 240
      CNOLD(IX,IY)=CONC(IX,IY)                                          G 250
      IF (THCK(IX,IY).EQ.0.0) GO TO 10                                  USNRC
      IF (NPCELL(IX,IY).GT.0.0)                                         USNRC
     1 CONC(IX,IY)= 0.5*(CONC(IX,IY) + SUMC(IX,IY)/(1.0*NPCELL(IX,IY))) USNRC
   10 CNCNC(IX,IY)=0.0                                                  G 260
      TVA=AREA*TIMV                                                     G 290
      ARPOR=AREA*POROS                                                  G 300
C     ************************************************************      G 310
C     ---CONC. CHANGE FOR TIMV DUE TO:                                  G 320
C           RECHARGE, PUMPING, LEAKAGE, DECAY , SORBTION---             G 330
   20 DO 60 IX=1,NX                                                     G 350
      DO 60 IY=1,NY                                                     G 360
      IF (THCK(IX,IY).EQ.0.0) GO TO 60                                  G 370
      CSTAR = CONC(IX,IY)                                               USNRC
      IF (NPCELL(IX,IY).GT.0) CSTAR = SUMC(IX,IY)/(1.0*NPCELL(IX,IY))   USNRC
      CKM1 = 2.0*CONC(IX,IY) - CSTAR                                    USNRC
      DIST = 0.0                                                        USNRC
      IF (NSORB.LT.1) GO TO 50                                          USNRC
      IF (NSORB.GT.1) GO TO 30                                          USNRC
C***  *****************LINEAR SORBTION**************                    USNRC
      DIST = SRBRAT*BLKDEN                                              USNRC
      GO TO 50                                                          USNRC
   30 IF (NSORB.GT.2) GO TO 40                                          USNRC
C***  ******************LANGMUIR SORBTION*************                   USNRC
      DIST = BLKDEN*SRBRAT*SRBSAT/(1.0+SRBRAT*CKM1)**2.0                USNRC
      GO TO 50
   40 IF (SRBALF.EQ.0.0) GO TO 50
C***  *****************FREUNDLICH SORBTION**********
      LOGCON = -23.0
      IF (CKM1.GT.1.0E-10) LOGCON = ALOG(CKM1)
      SRBEXP = (SRBALF-1.0)*LOGCON
      IF (SRBEXP.GT.23.0) SRBEXP = 23.0
      DIST = BLKDEN*SRBALF*SRBRAT*EXP(SRBEXP)
   50 EQFCT1=TIMV/((1.0+DIST)*THCK(IX,IY))
      EQFCT2=EQFCT1/POROS
      DELC = 0.0
      DELCR = CNRECH(IX,IY) - CONC(IX,IY)
C         ---ACCOUNT FOR BOUNDARY FLOW---
      FLW = VPRM(IX,IY)*(WT(IX,IY)-HK(IX,IY))
C            ---MASS IN BOUNDARY DURING TIME STEP---
      IF (FLW.GT.0.0) FLMIN=FLMIN+FLW*CNRECH(IX,IY)*TVA
C            ---MASS OUT DURING TIME STEP---
      IF (FLW.LT.0.0) FLMOT=FLMOT+FLW*CONC(IX,IY)*TVA
      IF (FLW.GT.0.0) DELC = DELC + FLW*DELCR
C         ---ACCOUNT FOR MASS PUMPED IN, OUT, RECHARGED, + DISCHARGED---
      RATE = REC(IX,IY)*ARINV
      IF (RATE.GT.0.0) CMSOUT=CMSOUT+RATE*CONC(IX,IY)*TVA
      IF (RATE.LT.0.0) CMSIN=CMSIN+RATE*CNRECH(IX,IY)*TVA
      IF (RATE.LT.0.0) DELC = DELC - RATE*DELCR
      QRECH = RECH(IX,IY)
      IF (QRECH.GT.0.0) CMSOUT=CMSOUT+QRECH*CONC(IX,IY)*TVA
      IF (QRECH.LT.0.0) CMSIN=CMSIN+QRECH*CNRECH(IX,IY)*TVA
      IF (QRECH.LT.0.0) DELC = DELC - QRECH*DELCR
      DELDCY = 0.0
      IF (NDECAY.GT.0) DELDCY =
     1    THCK(IX,IY)*POROS*CONC(IX,IY)*(EXP(-DCYLAM*TIMV)-1.0)/TIMV
      IF (NDECAY.GT.0) VOLDCY = VOLDCY + DELDCY*TVA
      IF (NDECAY.GT.0.AND.NSORB.GT.0) SRBDCY = SRBDCY + DIST*DELDCY*TVA
      IF (NDECAY.GT.0.AND.NSORB.GT.0) DELDCY = DELDCY + DIST*DELDCY
      DELC = DELC + DELDCY
      DELC = DELC*EQFCT2
      CNCNC(IX,IY) = CNCNC(IX,IY) + DELC
C     ---CONC. CHANGE DUE TO DISPERSION---
C         ---DISPERSION WITH TENSOR COEFFICIENTS---
      DELCD = 0.0
      IF (BETA.EQ.0.0) GO TO 55
      X1=DISP(IX,IY,1)*(CONC(IX+1,IY)-CONC(IX,IY))
      X2=DISP(IX-1,IY,1)*(CONC(IX-1,IY)-CONC(IX,IY))
      Y1=DISP(IX,IY,2)*(CONC(IX,IY+1)-CONC(IX,IY))
      Y2=DISP(IX,IY-1,2)*(CONC(IX,IY-1)-CONC(IX,IY))
      XX1=DISP(IX,IY,3)*(CONC(IX,IY+1)+CONC(IX+1,IY+1)-CONC(IX,IY-1)-CON
     1C(IX+1,IY-1))
      XX2=DISP(IX-1,IY,3)*(CONC(IX,IY+1)+CONC(IX-1,IY+1)-CONC(IX,IY-1)-C
     1ONC(IX-1,IY-1))
      YY1=DISP(IX,IY,4)*(CONC(IX+1,IY)+CONC(IX+1,IY+1)-CONC(IX-1,IY)-CON
     1C(IX-1,IY+1))
      YY2=DISP(IX,IY-1,4)*(CONC(IX+1,IY)+CONC(IX+1,IY-1)-CONC(IX-1,IY)-C
     1ONC(IX-1,IY-1))
      DELCD = EQFCT1*(X1+X2+Y1+Y2+XX1-XX2+YY1-YY2)*(1.0+DIST)
   55 CNCNC(IX,IY) = CNCNC(IX,IY) + DELCD
C         ---COMPUTE MASS OF SOLUTE IN STORAGE---
      STORM = STORM + (CSTAR+DELC+DELCD)*THCK(IX,IY)*ARPOR
C         ---COMPUTE CHANGE OF SORBED SOLUTE---
      IF (NSORB.GT.0) VOLSRB = VOLSRB +
     1                DIST*THCK(IX,IY)*ARPOR*(DELC+DELCD+CSTAR-CKM1)
   60 CONTINUE
      DO 90 IX=1,NX
      DO 90 IY=1,NY
      IF (THCK(IX,IY).EQ.0.0) GO TO 90
      APC=NPCELL(IX,IY)
      IF (APC.GT.0.0) GO TO 80
      IF (REC(IX,IY).NE.0.0.OR.VPRM(IX,IY).GT.0.09) GO TO 90            G 900
      NZERO=NZERO+1                                                     G 910
      GO TO 90                                                          G 920
   80 CONC(IX,IY)=SUMC(IX,IY)/APC                                       G 930
   90 CONTINUE                                                          G 940
C          ---CHECK NUMBER OF CELLS VOID OF PTS.---                     G 950
      IF (NZERO.GT.0) WRITE (6,290) NZERO,IMOV                          G 960
      IF (NZERO.LE.NZCRIT) GO TO 110                                    USNRC
      TEST=99.0                                                         G 980
      WRITE (6,300)                                                     G 990
      WRITE (6,320)                                                     G1000
      DO 100 IY=1,NY                                                    G1010
  100 WRITE (6,330) (NPCELL(IX,IY),IX=1,NX)                             G1020
      GO TO 110                                                         USNRC
C     ***************************************************************** G1040
C     ---CHANGE CONCENTRATIONS AT NODES---                              G1050
  110 DO 130 IX=1,NX                                                    G1060
      DO 130 IY=1,NY                                                    G1070
      IF (THCK(IX,IY).EQ.0.0) GO TO 120                                 G1080
      CONC(IX,IY)=CONC(IX,IY)+CNCNC(IX,IY)                              G1090
      SUMC(IX,IY)=0.0                                                   G1110
      IF (CONC(IX,IY).LE.0.0) GO TO 130                                 G1120
      CNCPCT=CNCNC(IX,IY)/CONC(IX,IY)                                   G1130
      SUMC(IX,IY)=CNCPCT                                                G1140
      GO TO 130                                                         G1150
  120 IF (CONC(IX,IY).GT.0.0) WRITE (6,310) IX,IY,CONC(IX,IY)           G1160
      CONC(IX,IY)=0.0                                                   G1170
  130 CONTINUE                                                          G1180
C     ***************************************************************** G1190
C     ---CHANGE CONCENTRATION OF PARTICLES---                           G1200
      DO 180 IN=1,NP                                                    G1210
      IF (PART(1,IN).EQ.0.0) GO TO 180                                  G1220
      INX=ABS(PART(1,IN))+0.5                                           G1230
      INY=ABS(PART(2,IN))+0.5                                           G1240
C     ---UPDATE CONC. OF PTS. IN SINK/SOURCE CELLS---                   G1250
      IF (REC(INX,INY).NE.0.0) GO TO 140                                G1260
      IF (VPRM(INX,INY).LE.0.09) GO TO 150                              G1270
  140 PART(3,IN)=CONC(INX,INY)                                          G1280
      GO TO 180                                                         G1290
  150 IF (CNCNC(INX,INY).LT.0.0) GO TO 170                              G1300
  160 PART(3,IN)=PART(3,IN)+CNCNC(INX,INY)                              G1310
      GO TO 180                                                         G1320
  170 IF (CONC(INX,INY).LE.0.0) GO TO 160                               G1330
      IF (SUMC(INX,INY).LT.-1.0) GO TO 160                              G1340
      PART(3,IN)=PART(3,IN)+PART(3,IN)*SUMC(INX,INY)                    G1350
  180 CONTINUE                                                          G1360
      WRITE (6,280) TIM(N),TIMV,SUMTCH                                  G1370
C     ***************************************************************** G1380
C     ---COMPUTE MASS BALANCE FOR SOLUTE---                             G1390
      DO 270 IX=1,NX                                                    G1420
      DO 270 IY=1,NY                                                    G1430
      IF (THCK(IX,IY).EQ.0.0) GO TO 270                                 G1440
      SUMC(IX,IY)=0.0                                                   G1450
      NPOLD(IX,IY)=NPCELL(IX,IY)                                        USNRC
      NPCELL(IX,IY)=0                                                   G1684
  270 CONTINUE                                                          G1690
C     ***************************************************************** G1700
C          ---COMPUTE CHANGE IN MASS OF SOLUTE STORED---                G1710
      CSTORM=STORM-STORMI                                               G1720
      SUMIO=FLMIN+FLMOT-CMSIN-CMSOUT                                    G1730
C     ***************************************************************** G1740
C     ---REGENERATE PARTICLES IF "NZCRIT" EXCEEDED---                   G1750
      IF (TEST.GT.98.0) CALL GENPT                                      G1760
      TEST=0.0                                                          G1770
      IF (NSORB.GT.1) CALL VELNEW (CNOLD)                               USNRC
C     ***************************************************************** G1780
```

```
      RETURN
C     **************************************************************
C
C
C
  280 FORMAT (3H    ,11HTIM(N)    = ,1P1E12.5,10X,11HTIMv       = ,1P1E12.5,
     110X,9HSUMTCH = ,1P1E12.5)
  290 FORMAT (1H0,5X,40HNUMBER OF CELLS WITH ZERO PARTICLES   =   ,I4,5X,9
     1HIMOV   =   ,I4/)
  300 FORMAT (1H0,5X,44H***   NZCRIT EXCEEDED  ---   CALL GENPT    ***/)
  310 FORMAT (1H ,5X,37H***CONC.GT.0.AND.THCK.EQ.0 AT NODE = ,2I4,4X,7HC
     1ONC = ,1P1E10.4,4H ***)
  320 FORMAT (1H0,2X,6HNPCELL/)
  330 FORMAT (1H ,4X,20I3)
      END
```

```
**** TSO FOREGROUND HARDCOPY ****
DSNAME=U11236C.KONIMOD.CNTL
                                                        (OUTPT    )
C   USE META COMMANDS (BELOW) WHEN COMPILED ON MICROCOMPUTER
C   $NOFLOATCALLS
C   $STORAGE:2
      SUBROUTINE OUTPT
      CHARACTER*8 TITLE                                                 H  10
      REAL*8 TMRX,VPRM,HI,HR,HC,HK,WT,REC,RECH,TIM,ADPT                 H  11
      REAL*8 XDEL,YDEL,S,AREA,SUMT,RHO,PARAM,TEST,TOL,PINT,HMIN,PYR     H  20
      REAL*8 HJ                                                         H  30
      INTEGER FCON                                                      H  35
      COMMON /PRMI/ NTIM,NPMP,NPNT,NITP,N,NX,NY,NP,NREC,INT,NNX,NNY,NUMO H  36
     1BS,NMOV,IMOV,NPMAX,ITMAX,NZCRIT,IPRNT,NPTPND,NPNTMV,NPNTVL,NPNTD,N H  40
     2PNCHV,NPDELC,ICHK,FCON,IHEAD,ISOLV                                H  50
      COMMON /PRMC/ NODEID(20,20),NPCELL(20,20),NPOLD(20,20),LIMBO(500), H  62
     1IXOBS(5),IYOBS(5)                                                 H  65
     2,NDECAY,NSORB                                                     H  66
      COMMON /HEDA/ THCK(20,20),PERM(20,20),TMWL(5,50),TMOBS(50),ANFCTR  USNRC
     1,THICK(20,20)                                                     H  90
      COMMON /HEDB/ TMRX(20,20,2),VPRM(20,20),HI(20,20),HR(20,20),HC(20, H  91
     120),HK(20,20),WT(20,20),REC(20,20),RECH(20,20),TIM(100),ADPT(20),T H 100
     2ITLE(10),XDEL,YDEL,S,AREA,SUMT,RHO,PARAM,TEST,TOL,PINT,HMIN,PYR   H 110
     3,HJ(20,20)                                                        H 120
      COMMON /BALM/ TOTLQ,TOTLQI,TPIN,TPOUT,TPQR                        H 125
      DIMENSION IH(20),TRANS(20)                                        H 127
C     ***************************************************************** H 140
      TIMD=SUMT/86400.                                                  H 150
      TIMY=SUMT/(86400.0*365.25)                                        H 160
C     ---PRINT HEAD VALUES---                                           H 170
      WRITE (6,120)                                                     H 180
      WRITE (6,130) N                                                   H 190
      WRITE (6,140) SUMT                                                H 200
      WRITE (6,150) TIMD                                                H 210
      WRITE (6,160) TIMY                                                H 220
      WRITE (6,170)                                                     H 230
      DO 10 IY=1,NY                                                     H 240
   10 WRITE (6,180) (HK(IX,IY),IX=1,NX)                                 H 250
      IF (N.EQ.0) GO TO 110                                             H 260
C     ***************************************************************** H 270
C     ---PRINT HEAD MAP---                                              H 280
      WRITE (6,120)                                                     H 290
      WRITE (6,130) N                                                   H 300
      WRITE (6,140) SUMT                                                H 310
      WRITE (6,150) TIMD                                                H 320
      WRITE (6,160) TIMY                                                H 330
      WRITE (6,170)                                                     H 340
      DO 30 IY=1,NY                                                     H 350
      DO 20 IX=1,NX                                                     H 360
   20 IH(IX)=HK(IX,IY)+0.5                                              H 370
   30 WRITE (6,190) (IH(ID),ID=1,NX)                                    H 380
C     ***************************************************************** H 390
C     ---COMPUTE WATER BALANCE AND DRAWDOWN---                          H 400
      QSTR=0.0                                                          H 410
      PUMP=0.0                                                          H 420
      PQIN=0.0                                                          H 430
      PQOUT=0.0                                                         H 432
      TPUM=0.0                                                          H 434
      QIN=0.0                                                           H 440
      QOUT=0.0                                                          H 450
      QNET=0.0                                                          H 460
      DELQ=0.0                                                          H 470
      PCTERR=0.0                                                        H 480
      PQR = 0.0                                                         H 500
      WRITE (6,290)                                                     H 501
                                                                        H 510
```

```
C                                                                       H 520
      DO 80 IY=1,NY                                                     H 530
      DO 70 IX=1,NX                                                     H 540
      IH(IX)=0.0                                                        H 550
      IF (THCK(IX,IY).EQ.0.0) GO TO 70                                  H 560
      IF (REC(IX,IY).GT.0.0) GO TO 32                                   H 562
      PQIN=PQIN+REC(IX,IY)                                              H 564
      GO TO 34                                                          H 566
   32 PQOUT=PQOUT+REC(IX,IY)                                            H 568
   34 IF (RECH(IX,IY).GT.0.0) GO TO 36                                  H 572
      PQR=PQR+RECH(IX,IY)*AREA                                          H 575
      GO TO 38                                                          H 576
   36 PQOUT=PQOUT+RECH(IX,IY)*AREA                                      H 578
   38 IF (VPRM(IX,IY).EQ.0.0) GO TO 60                                  H 582
      DELQ=VPRM(IX,IY)*AREA*(WT(IX,IY)-HK(IX,IY))                       H 590
      IF (DELQ.GT.0.0) GO TO 40                                         H 600
      QOUT=QOUT+DELQ                                                    H 610
      GO TO 50                                                          H 620
   40 QIN=QIN+DELQ                                                      H 630
   50 QNET=QNET+DELQ                                                    H 640
   60 DDRW=HI(IX,IY)-HK(IX,IY)                                          H 650
      IH(IX)=DDRW+0.5                                                   H 660
      QSTR=QSTR+DDRW*AREA*S                                             H 670
   70 CONTINUE                                                          H 680
C        ---PRINT DRAWDOWN MAP---                                       H 690
      WRITE (6,300) (IH(IX),IX=1,NX)                                    H 700
   80 CONTINUE                                                          H 710
C        ---PRINT THICKNESS MAP---                                      H 711
      IF (FCON .EQ. 0) GO TO 75                                         H 712
      WRITE (6,310)                                                     H 713
      DO 85 IY=1,NY                                                     H 715
      WRITE (6,320) (THCK(IX,IY),IX=1,NX)                               H 716A
   85 CONTINUE                                                          H 718
C        ---PRINT TRANSMISSIVITY MAP---                                 H 719
      WRITE (6,330)                                                     H 720
      DO 90 IY=1,NY                                                     H 722
      DO 95 IX=1,NX                                                     H 723
      TRANS(IX)=PERM(IX,IY)*THCK(IX,IY)                                 H 724
   95 CONTINUE                                                          H 725
      WRITE (6,340) (TRANS(IX),IX=1,NX)                                 H 726
   90 CONTINUE                                                          H 728
   75 CONTINUE                                                          H 729
      TPUM = PQIN + PQR + PQOUT                                         H 730
      PUMP = TPIN + TPQR + TPOUT                                        H 740
      TOTLQN=TOTLQ+TOTLQI                                               H 745
      SRCS=QSTR-TPIN-TOTLQI-TPQR                                        H 757
      SINKS=TPOUT+TOTLQ                                                 H 766
      ERRMB=SRCS-SINKS                                                  H 775
      DENOM=(SRCS+SINKS)*0.5                                            H 785
      IF (DENOM.EQ.0.0) GO TO 100                                       H 795
      PCTERR=ERRMB*100.0/DENOM                                          H 805
C        ---PRINT MASS BALANCE DATA FOR FLOW MODEL---                   H 830
  100 WRITE (6,240)                                                     H 840
      WRITE (6,215) TPQR                                                H 841
      WRITE (6,211) TPIN                                                H 842
      WRITE (6,212) TPOUT                                               H 844
      WRITE (6,250) PUMP                                                H 850
      WRITE (6,230) QSTR                                                H 860
      WRITE (6,202) TOTLQI                                              H 862
      WRITE (6,203) TOTLQ                                               H 864
      WRITE (6,260) TOTLQN                                              H 866
      WRITE (6,270) ERRMB                                               H 880
      WRITE (6,280) PCTERR                                              H 883
      WRITE (6,201)                                                     H 886
      WRITE (6,215) PQR                                                 H 887
      WRITE (6,202) QIN                                                 H 889
      WRITE (6,203) QOUT
      WRITE (6,204) QNET                                                H 892
      WRITE (6,211) PQIN                                                H 895
      WRITE (6,212) PQOUT                                               H 898
      WRITE (6,210) TPUM                                                H 901
C     ***********************************************************      H 910
  110 RETURN                                                            H 940
C     ***********************************************************      H 950
C                                                                       H 960
C                                                                       H 970
C                                                                       H 980
  120 FORMAT (1H1,23HHEAD DISTRIBUTION - ROW)                           H 990
  130 FORMAT (1X,23HNUMBER OF TIME STEPS = ,1I5)                        H1000
  140 FORMAT (8X,16HTIME(SECONDS) = ,1P1E12.5)                          H1010
  150 FORMAT (8X,16HTIME(DAYS)    = ,1P1E12.5)                          H1020
  160 FORMAT (8X,16HTIME(YEARS)   = ,1P1E12.5)                          H1030
  170 FORMAT (1H )                                                      H1040
  180 FORMAT (1H0,10F12.7)                                              H1050
  190 FORMAT (1H0,20I4)                                                 H1055
  201 FORMAT (1H0,2X,33HRATE MASS BALANCE -- (IN C.F.S.) //)            H1070
  202 FORMAT (4X,29HLEAKAGE INTO AQUIFER          = ,1P1E12.5)          H1073
  203 FORMAT (4X,29HLEAKAGE OUT OF AQUIFER        = ,1P1E12.5)          H1076
  204 FORMAT (4X,29HNET LEAKAGE     (QNET)        = ,1P1E12.5)          H1083
  210 FORMAT (4X,29HNET WITHDRAWAL    (TPUM)      = ,1P1E12.5)          H1086
  211 FORMAT (4X,29HINJECTION                     = ,1P1E12.5)          H1093
  212 FORMAT (4X,29HPUMPAGE                       = ,1P1E12.5)          H1095
  215 FORMAT (4X,29HRECHARGE                      = ,1P1E12.5)          H1100
  230 FORMAT (4X,29HWATER RELEASE FROM STORAGE = ,1P1E12.5)             H1110
  240 FORMAT (1H0,2X,38HCUMULATIVE MASS BALANCE -- (IN FT**3) //)       H1120
  250 FORMAT (4X,29HCUMULATIVE  NET  PUMPAGE    = ,1P1E12.5)            H1125
  260 FORMAT (4X,29HCUMULATIVE  NET  LEAKAGE    = ,1P1E12.5)            H1140
  270 FORMAT (1H0,7X,25HMASS BALANCE RESIDUAL  = ,1P1E12.5)             H1150
  280 FORMAT (1H ,7X,25HERROR  (AS PERCENT)    = ,1P1E12.5/)            H1160
  290 FORMAT (1H1,8HDRAWDOWN)                                           H1170
  300 FORMAT (3H   ,20I5)                                               H1180
  310 FORMAT (1H1,17HAQUIFER THICKNESS)                                 H1190
  320 FORMAT (3H   ,20F5.1)                                             H1192
  330 FORMAT (1H1,14HTRANSMISSIVITY)                                    H1194
  340 FORMAT (3H   ,20F5.2)                                             H1196
      END                                                               H1198
                                                                        H1200-
```

```
**** TSO FOREGROUND HARDCOPY ****
DSNAME=U11236C.KONIMOD.CNTL                          (CHMOT    )

C  USE META COMMANDS (BELOW) WHEN COMPILED ON MICROCOMPUTER
C  $NOFLOATCALLS
C  $STORAGE:2
      SUBROUTINE CHMOT                                                    I   10
      CHARACTER*8 TITLE                                                   I   11
      REAL*8 TMRX,VPRM,HI,HR,HC,HK,WT,REC,RECH,TIM,AOPT                   I   20
      REAL*8 XDEL,YDEL,S,AREA,SUMT,RHO,PARAM,TEST,TOL,PINT,HMIN,PYR       I   30
      REAL*8 HJ                                                           I   35
      INTEGER FCON                                                        I   36
      COMMON /PRMI/ NTIM,NPMP,NPNT,NITP,N,NX,NY,NP,NREC,INT,NNX,NNY,NUMO  I   40
     1BS,NMOV,IMOV,NPMAX,ITMAX,NZCRIT,IPRNT,NPTPND,NPNTMV,NPNTVL,NPNTD,N  I   50
     2PNCHV,NPDELC,ICHK,FCON,IHEAD,ISOLV                                  I   62
      COMMON /PRMC/ NODEID(20,20),NPCELL(20,20),NPOLD(20,20),LIMBO(500),  I   65
     1IXOBS(5),IYOBS(5)                                                   I   66
     2,NDECAY,NSORB                                                        USNRC
      COMMON /HEDA/ THCK(20,20),PERM(20,20),TMWL(5,50),TMOBS(50),ANFCTR   I   90
     1,THICK(20,20)                                                       I   91
      COMMON /HEDB/ TMRX(20,20,2),VPRM(20,20),HI(20,20),HR(20,20),HC(20,  I  100
     120),HK(20,20),WT(20,20),REC(20,20),RECH(20,20),TIM(100),AOPT(20),T  I  110
     2ITLE(10),XDEL,YDEL,S,AREA,SUMT,RHO,PARAM,TEST,TOL,PINT,HMIN,PYR     I  120
     3,HJ(20,20)                                                          I  125
      COMMON /CHMA/ PART(3,3200),CONC(20,20),TMCN(5,50),VX(20,20),VY(20,  I  130
     120),CONINT(20,20),CNRECH(20,20),POROS,SUMTCH,BETA,TIMV,STORM,STORM  I  140
     2I,CMSIN,CMSOUT,FLMIN,FLMOT,SUMIO,CELDIS,DLTRAT,CSTORM               I  150
     3,DCYLAM,BLKDEN,SRBRAT,SRBSAT,SRBALF,VOLDCY,VOLSRB,SRBDCY             USNRC
      DIMENSION IC(20)                                                    I  160
C     ***************************************************************     I  170
      TMFY=86400.0*365.25                                                 I  180
      TMYR=SUMT/TMFY                                                      I  190
      TCHD=SUMTCH/86400.0                                                 I  200
      TCHYR=SUMTCH/TMFY                                                   I  210
      ERR1=0.0                                                            I  212
      ERR3=0.0                                                            I  214
      IF (IPRNT.GT.0) GO TO 100                                           I  220
C     ***************************************************************     I  230
C     ---PRINT CONCENTRATIONS---                                          I  240
      WRITE (6,160)                                                       I  250
      WRITE (6,170) N                                                     I  260
      IF (N.GT.0) WRITE (6,180) TIM(N)                                    I  270
      WRITE (6,190) SUMT                                                  I  280
      WRITE (6,450) SUMTCH                                                I  290
      WRITE (6,200) TCHD                                                  I  300
      WRITE (6,210) TMYR                                                  I  310
      WRITE (6,460) TCHYR                                                 I  320
      WRITE (6,380) IMOV                                                  I  330
      WRITE (6,220)                                                       I  340
      DO 5 IY=1,NY                                                        I  344
    5 WRITE (6,245) (CONC(IX,IY),IX=1,NX)                                 I  346
      WRITE (6,160)                                                       I  347
      WRITE (6,170) N                                                     I  348
      WRITE (6,220)                                                       I  349
      DO 20 IY=1,NY                                                       I  350
      DO 10 IX=1,NX                                                       I  360
   10 IC(IX)=CONC(IX,IY)+0.5                                              I  370
   20 WRITE (6,240) (IC(IX),IX=1,NX)                                      I  380
C     ***************************************************************     I  390
      IF (N.EQ.0) GO TO 150                                               I  400
      IF (NPDELC.EQ.0) GO TO 50                                           I  410
C                                                                         I  420
C     ---PRINT CHANGES IN CONCENTRATION---                                I  430
      WRITE (6,230)                                                       I  440
      WRITE (6,170) N                                                     I  450
      WRITE (6,180) TIM(N)
      WRITE (6,190) SUMT                                                I 460
      WRITE (6,450) SUMTCH                                              I 470
      WRITE (6,200) TCHD                                                I 480
      WRITE (6,210) TMYR                                                I 490
      WRITE (6,460) TCHYR                                               I 500
      WRITE (6,380) IMOV                                                I 510
      WRITE (6,220)                                                     I 520
      DO 40 IY=1,NY                                                     I 530
      DO 30 IX=1,NX                                                     I 540
      CNG=CONC(IX,IY)-CONINT(IX,IY)                                     I 550
   30 IC(IX)=CNG                                                        I 560
   40 WRITE (6,240) (IC(IX),IX=1,NX)                                    I 570
C     ***************************************************************** I 580
C     ---PRINT MASS BALANCE DATA FOR SOLUTE---                          I 590
   50 RESID=SUMIO-CSTORM + VOLDCY - VOLSRB + SRBDCY                     I 600
      SUMIN=FLMIN-CMSIN                                                 USNRC
      IF (SUMIN.EQ.0.0) GO TO 60                                        I 615
      ERR1=RESID*100.0/SUMIN                                            I 625
   60 IF (STORMI.EQ.0.0) GO TO 70                                       I 635
      ERR3=-100.0*RESID/(STORMI-SUMIO)                                  I 650
   70 WRITE (6,220)                                                     I 660
      WRITE (6,250)                                                     I 670
      WRITE (6,220)                                                     I 680
      WRITE (6,260) FLMIN                                               I 690
      WRITE (6,270) FLMOT                                               I 700
      RECIN=-CMSIN                                                      I 710
      RECOUT=-CMSOUT                                                    I 720
      WRITE (6,290) RECIN                                               I 730
      WRITE (6,280) RECOUT                                              I 740
      WRITE (6,300) SUMIO                                               I 750
      WRITE (6,310) STORMI                                              I 760
      WRITE (6,320) STORM                                               I 770
      WRITE (6,330) CSTORM                                              I 780
      IF (NDECAY.GT.0) WRITE (6,333) VOLDCY                             I 790
      IF (NSORB.GT.0) WRITE (6,335) VOLSRB                              USNRC
      IF (NSORB.GT.0.AND.NDECAY.GT.0) WRITE (6,336) SRBDCY              USNRC
      WRITE (6,340)                                                     USNRC
      WRITE (6,350) RESID                                               I 810
      WRITE (6,360) ERR1                                                I 820
   80 IF (STORMI.EQ.0.0) GO TO 90                                       I 830
      WRITE (6,370)                                                     I 840
      WRITE (6,360) ERR3                                                I 850
C     ***************************************************************** I 860
C     ---PRINT HYDROGRAPHS AFTER 50 STEPS OR END OF SIMULATION---       I 870
   90 IF (MOD(IMOV,50).EQ.0.AND.S.EQ.0.0) GO TO 100                     I 880
      IF (MOD(N,50).EQ.0.AND.S.GT.0.0) GO TO 100                        I 890
      IF (S.EQ.0.0.AND.N.LT.NTIM.AND.INT.GT.0) GO TO 100                I 900
      GO TO 150                                                         I 905
  100 WRITE (6,390) TITLE                                               I 910
      IF (NUMOBS.LE.0) GO TO 150                                        I 920
      WRITE (6,400) INT                                                 I 930
      IF (S.GT.0.0) WRITE (6,410)                                       I 940
      IF (S.EQ.0.0) WRITE (6,420)                                       I 950
C        ---TABULATE HYDROGRAPH DATA---                                 I 960
      MOZ=0                                                             I 970
      IF (S.GT.0.0) GO TO 110                                           I 980
      NTO=NMOV                                                          I 990
      IF (NMOV.GT.50) NTO=MOD(IMOV,50)                                  I1000
      GO TO 120                                                         I1010
  110 NTO=NTIM                                                          I1020
      IF (NTIM.GT.50) NTO=MOD(N,50)                                     I1030
  120 IF (NTO.EQ.0) NTO=50                                              I1040
      DO 140 J=1,NUMOBS                                                 I1050
      TMYR=0.0                                                          I1060
      WRITE (6,430) J,IXOBS(J),IYOBS(J)                                 I1070
                                                                        I1080
      WRITE (6,440) MOZ,WT(IXOBS(J),IYOBS(J)),CONINT(IXOBS(J),IYOBS(J)),  I1090
     1TMYR                                                                 I1100
      DO 130 M=1,NTO                                                       I1110
      TMYR=TMOBS(M)/TMFY                                                   I1120
      WRITE (10,445) INT,N,J,M,TMWL(J,M),TMCN(J,M),TMYR                    I1125
  130 WRITE (6,440) M,TMWL(J,M),TMCN(J,M),TMYR                             I1130
  140 CONTINUE                                                             I1140
C     ***************************************************************     I1150
  150 IPRNT = 0                                                            I1155
      RETURN                                                               I1165
C     ***************************************************************     I1170
C                                                                          I1180
C                                                                          I1190
C                                                                          I1200
  160 FORMAT (1H1,13HCONCENTRATION/)                                       I1210
  170 FORMAT (1X,23HNUMBER OF TIME STEPS = ,1I5)                           I1220
  180 FORMAT (8X,16HDELTA T        = ,1P1E12.5)                            I1230
  190 FORMAT (8X,16HTIME(SECONDS) = ,1P1E12.5)                             I1240
  200 FORMAT (3X,21HCHEM.TIME(DAYS)      = ,1P1E12.5)                      I1250
  210 FORMAT (8X,16HTIME(YEARS)    = ,1P1E12.5)                            I1260
  220 FORMAT (1H )                                                         I1270
  230 FORMAT (1H1,23HCHANGE IN CONCENTRATION/)                             I1280
  240 FORMAT (1H0,20I5)                                                    I1290
  245 FORMAT (1H0,10F10.4)                                                 I1295
  250 FORMAT (1H ,21HCHEMICAL MASS BALANCE)                                I1300
  260 FORMAT (8X,25HMASS IN BOUNDARIES       = ,1P1E12.5)                  I1310
  270 FORMAT (8X,25HMASS OUT BOUNDARIES      = ,1P1E12.5)                  I1320
  280 FORMAT (8X,25HMASS PUMPED OUT          = ,1P1E12.5)                  I1330
  290 FORMAT (8X,25HMASS PUMPED IN           = ,1P1E12.5)                  I1340
  300 FORMAT (8X,25HINFLOW MINUS OUTFLOW     = ,1P1E12.5)                  I1350
  310 FORMAT (8X,25HINITIAL MASS STORED      = ,1P1E12.5)                  I1360
  320 FORMAT (8X,25HPRESENT MASS STORED      = ,1P1E12.5)                  I1370
  330 FORMAT (8X,25HCHANGE MASS STORED       = ,1P1E12.5)                  I1380
  333 FORMAT (8X,25HDECAY OF SOLUTE MASS     = ,1P1E12.5)                  USNRC
  335 FORMAT (8X,25HSORBTION STORAGE (S)     = ,1P1E12.5)                  USNRC
  336 FORMAT (8X,25HSORBTION DECAY (S)       = ,1P1E12.5).                 USNRC
  340 FORMAT (1H ,5X,53HCOMPARE RESIDUAL WITH NET FLUX AND MASS ACCUMULA  I1390
     1TION:)                                                               I1400
  350 FORMAT (8X,25HMASS BALANCE RESIDUAL  = ,1P1E12.5)                    I1410
  360 FORMAT (8X,25HERROR  (AS PERCENT)      = ,1P1E12.5)                  I1420
  370 FORMAT (1H ,5X,55HCOMPARE INITIAL MASS STORED WITH CHANGE IN MASS   I1430
     1STORED:)                                                             I1440
  380 FORMAT (1X,23H NO. MOVES COMPLETED = ,1I5)                           I1450
  390 FORMAT (1H1,10A8//)                                                  I1460
  400 FORMAT (1H0,5X,65HTIME VERSUS HEAD AND CONCENTRATION AT SELECTED O  I1470
     1BSERVATION POINTS//15X,19HPUMPING PERIOD NO. ,I4////)                I1480
  410 FORMAT (1H0,16X,19HTRANSIENT  SOLUTION////)                          I1490
  420 FORMAT (1H0,15X,21HSTEADY-STATE SOLUTION////)                        I1500
  430 FORMAT (1H0,20X,22HOBS.WELL NO.    X     Y,17X,1HN,6X,40HHEAD (FT)  I1510
     1   CONC.(MG/L)    TIME (YEARS)//17X,I3,9X,I2,3X,I2//)                I1520
  440 FORMAT (1H ,58X,I2,6X,F7.1,8X,F7.1,8X,F7.3)                          I1531
  445 FORMAT (1H ,4I4,3F7.3)                                               I1535
  450 FORMAT (1H ,2X,21HCHEM.TIME(SECONDS) = ,1P1E12.5)                    I1540
  460 FORMAT (1H ,2X,21HCHEM.TIME(YEARS)   = ,1P1E12.5)                    I1550
      END                                                                  I1560-
```

```
**** TSO FOREGROUND HARDCOPY ****
DSNAME=U11236C.KONIMOD.CNTL                          (VELNEW  )

C  USE META COMMANDS (BELOW) WHEN COMPILED ON MICROCOMPUTER
C  $NOFLOATCALLS
C  $STORAGE:2
      SUBROUTINE VELNEW (CNOLD)
      CHARACTER*8 TITLE
      REAL*8 TMRX,VPRM,HI,HR,HC,HK,WT,REC,RECH,TIM,AOPT
      REAL*8 XDEL,YDEL,S,AREA,SUMT,RHO,PARAM,TEST,TOL,PINT,HMIN,PYR
      REAL*8 RATE,SLEAK,DIV
      REAL*8 HJ
      INTEGER FCON
      COMMON /PRMI/ NTIM,NPMP,NPNT,NITP,N,NX,NY,NP,NREC,INT,NNX,NNY,NUMO
     1BS,NMOV,IMOV,NPMAX,ITMAX,NZCRIT,IPRNT,NPTPND,NPNTMV,NPNTVL,NPNTD,N
     2PNCHV,NPDELC,ICHK,FCON,IHEAD,ISOLV
      COMMON /PRMC/ NODEID(20,20),NPCELL(20,20),NPOLD(20,20),LIMBO(500),
     1IXOBS(5),IYOBS(5)
     2,NDECAY,NSORB
      COMMON /HEDA/ THCK(20,20),PERM(20,20),TMWL(5,50),TMOBS(50),ANFCTR
     1,THICK(20,20)
      COMMON /HEDB/ TMRX(20,20,2),VPRM(20,20),HI(20,20),HR(20,20),HC(20,
     120),HK(20,20),WT(20,20),REC(20,20),RECH(20,20),TIM(100),AOPT(20),T
     2ITLE(10),XDEL,YDEL,S,AREA,SUMT,RHO,PARAM,TEST,TOL,PINT,HMIN,PYR
     3,HJ(20,20)
      COMMON /XINV/ DXINV,DYINV,ARINV,PORINV
      COMMON /CHMA/ PART(3,3200),CONC(20,20),TMCN(5,50),VX(20,20),VY(20,
     120),CONINT(20,20),CNRECH(20,20),POROS,SUMTCH,BETA,TIMV,STORM,STORM
     2I,CMSIN,CMSOUT,FLMIN,FLMOT,SUMIO,CELDIS,DLTRAT,CSTORM
     3,DCYLAM,BLKDEN,SRBRAT,SRBSAT,SRBALF,VOLDCY,VOLSRB,SRBDCY
      COMMON /CHMC/ SUMC(20,20),VXBDY(20,20),VYBDY(20,20)
      COMMON /DIFUS/ DISP(20,20,4)
      DIMENSION CNOLD(20,20)
C     ************************************************************
C     -------------UPDATE VELOCITIES AND STORE------------
      VMAX = 0.0
      TDIV = 0.0
      TDIS = 0.0
      IXQMAX = 0
      IYQMAX = 0
      IF (IMOV.LT.2) ELPTIM = 0.0
      ELPTIM = ELPTIM + TIMV
      TIMREM = TIM(N) - ELPTIM
      RATIOT = TIMREM/TIM(N)
      IF (RATIOT.GT.1.0E-07) GO TO 10
      NMOV = IMOV
      RETURN
   10 DO 50 IX=1,NX
      DO 50 IY=1,NY
      DO 20 IZ=1,4
   20 DISP(IX,IY,IZ)=0.0
      IF (THCK(IX,IY).EQ.0.0) GO TO 50
      DISTN = 0.0
      DISTO = 0.0
      IF (NSORB.GT.2) GO TO 30
C***  *****************LANGMUIR SORBTION*******************************
      DISTN = BLKDEN*SRBRAT*SRBSAT/(1.0+SRBRAT*CONC(IX,IY))**2.0
      DISTO = BLKDEN*SRBRAT*SRBSAT/(1.0+SRBRAT*CNOLD(IX,IY))**2.0
      GO TO 40
   30 IF (SRBALF.EQ.0.0) GO TO 40
C***  *****************FREUNDLICH SORBTION*****************************
      DIST = BLKDEN*SRBRAT*SRBALF
      LOGCON = -23.0
      IF (CONC(IX,IY).GT.1.0E-10) LOGCON = ALOG(CONC(IX,IY))
      SRBEXP = (SRBALF-1.0)*LOGCON
      IF (SRBEXP.GT.23.0) SRBEXP = 23.0
      DISTN = DIST*EXP(SRBEXP)
      LOGCON = -23.0
      IF (CNOLD(IX,IY).GT.1.0E-10) LOGCON = ALOG(CNOLD(IX,IY))
      SRBEXP = (SRBALF-1.0)*LOGCON
      IF (SRBEXP.GT.23.0) SRBEXP = 23.0
      DISTO = DIST*EXP(SRBEXP)
   40 RETARD = (1.0+DISTO)/(1.0+DISTN)
C
C        ---UPDATE VELOCITIES AT NODES---
C           ---X-DIRECTION---
      VX(IX,IY) = VX(IX,IY)*RETARD
      VX2 = VX(IX,IY)*VX(IX,IY)
      IF (VX2.GT.VMAX) VMAX = VX2
C           ---Y-DIRECTION---
      VY(IX,IY) = VY(IX,IY)*RETARD
      VY2 =VY(IX,IY)*VY(IX,IY)
      IF (VY2.GT.VMAX) VMAX = VY2
C     ------VELOCITIES AT CELL BOUNDARIES------
      VXBDY(IX,IY) = VXBDY(IX,IY)*RETARD
      VX2 = VXBDY(IX,IY)*VXBDY(IX,IY)
      IF (VX2.GT.VMAX) VMAX = VX2
      VYBDY(IX,IY) = VYBDY(IX,IY)*RETARD
      VY2 = VYBDY(IX,IY)*VYBDY(IX,IY)
      IF (VY2.GT.VMAX) VMAX = VY2
      RATE = -REC(IX,IY)/AREA
      SLEAK = (WT(IX,IY)-HK(IX,IY))*VPRM(IX,IY)
      DIV = RATE+SLEAK-RECH(IX,IY)
      IF (DIV.LE.0.0) GO TO 50
      RTDIV = DIV/(POROS*THCK(IX,IY))
      IF (RTDIV.LT.TDIV) GO TO 50
      TDIV = RTDIV
      IXQMAX = IX
      IYQMAX = IY
   50 CONTINUE
      IF (BETA.EQ.0.0) GO TO 100
C     ****************************************************************
C     ---COMPUTE DISPERSION COEFFICIENTS---
      ALPHA=BETA
      ALNG=ALPHA
      TRAN=DLTRAT*ALPHA
      XX2=XDEL*XDEL
      YY2=YDEL*YDEL
      XY2=4.0*XDEL*YDEL
      DO 70 IX=2,NNX
      DO 70 IY=2,NNY
      IF (THCK(IX,IY).EQ.0.0) GO TO 70
      VXE=VXBDY(IX,IY)
      VYS=VYBDY(IX,IY)
      IF (THCK(IX+1,IY).EQ.0.0) GO TO 60
C        ---FORWARD COEFFICIENTS: X-DIRECTION---
      VYE=(VYBDY(IX,IY-1)+VYBDY(IX+1,IY-1)+VYS+VYBDY(IX+1,IY))/4.0
      VXE2=VXE*VXE
      VYE2=VYE*VYE
      VMGE=SQRT(VXE2+VYE2)
      IF (VMGE.LT.1.0E-20) GO TO 60
      DALN=ALNG*VMGE
      DTRN=TRAN*VMGE
      VMGE2=VMGE*VMGE
C           ---XX COEFFICIENT---
      DISP(IX,IY,1)=(DALN*VXE2+DTRN*VYE2)/(VMGE2*XX2)
C           ---XY COEFFICIENT---
      DISP(IX,IY,3)=(DALN-DTRN)*VXE*VYE/(VMGE2*XY2)
C        ---FORWARD COEFFICIENTS: Y-DIRECTION---
   60 IF (THCK(IX,IY+1).EQ.0.0) GO TO 70
      VXS=(VXBDY(IX-1,IY)+VXE+VXBDY(IX-1,IY+1)+VXBDY(IX,IY+1))/4.0
      VYS2=VYS*VYS
      VXS2=VXS*VXS
      VMGS=SQRT(VXS2+VYS2)
      IF (VMGS.LT.1.0E-20) GO TO 70
      DALN=ALNG*VMGS
      DTRN=TRAN*VMGS
      VMGS2=VMGS*VMGS
C           ---YY COEFFICIENT---
      DISP(IX,IY,2)=(DALN*VYS2+DTRN*VXS2)/(VMGS2*YY2)
C           ---YX COEFFICIENT---
      DISP(IX,IY,4)=(DALN-DTRN)*VXS*VYS/(VMGS2*XY2)
   70 CONTINUE
C     ************************************************************
C     ---ADJUST CROSS-PRODUCT TERMS FOR ZERO THICKNESS---
      DO 80 IX=2,NNX
      DO 80 IY=2,NNY
      IF (THCK(IX,IY+1).EQ.0.0.OR.THCK(IX+1,IY+1).EQ.0.0.OR.THCK(IX,IY-1
     1).EQ.0.0.OR.THCK(IX+1,IY-1).EQ.0.0) DISP(IX,IY,3)=0.0
      IF (THCK(IX+1,IY).EQ.0.0.OR.THCK(IX+1,IY+1).EQ.0.0.OR.THCK(IX-1,IY
     1).EQ.0.0.OR.THCK(IX-1,IY+1).EQ.0.0) DISP(IX,IY,4)=0.0
C     ************************************************************
C     ---CHECK FOR STABILITY OF EXPLICIT METHOD---
      TDISP = DISP(IX,IY,1)+DISP(IX,IY,2)
   80 IF (TDISP.GT.TDIS) TDIS = TDISP
C     ************************************************************
C     ---ADJUST DISP. EQUATION COEFFICIENTS FOR SATURATED THICKNESS---
      DO 90 IX=2,NNX
      DO 90 IY=2,NNY
      IF (THCK(IX,IY).EQ.0.0) GO TO 90
      BAVX=2.0*THCK(IX,IY)*THCK(IX+1,IY)/(THCK(IX,IY)+THCK(IX+1,IY))
      BAVY=2.0*THCK(IX,IY)*THCK(IX,IY+1)/(THCK(IX,IY)+THCK(IX,IY+1))
      DISP(IX,IY,1)=DISP(IX,IY,1)*BAVX
      DISP(IX,IY,2)=DISP(IX,IY,2)*BAVY
      DISP(IX,IY,3)=DISP(IX,IY,3)*BAVX
      DISP(IX,IY,4)=DISP(IX,IY,4)*BAVY
   90 CONTINUE
C     ************************************************************
C     ---COMPUTE NEXT TIME STEP---
  100 VMAX = SQRT(VMAX)
      RTADV = VMAX/(CELDIS*XDEL)
      TDIS = 2.0*TDIS
      RTMAX = AMAX1(RTADV,TDIV,TDIS)
      TIMV = 1.0/RTMAX
      NMOVRM = TIMREM/TIMV + 1
      TIMV = TIMREM/(1.0*NMOVRM)
      NMOV = IMOV + NMOVRM
      WRITE (6,6000) NMOVRM,N
      IF (RTMAX.EQ.RTADV) WRITE (6,6010)
      IF (RTMAX.EQ.TDIS) WRITE (6,6020)
      IF (RTMAX.EQ.TDIV) WRITE (6,6030) IXQMAX,IYQMAX
      RETURN
C     ************************************************************
C     -------OUTPUT FORMATS--------
C     ************************************************************
 6000 FORMAT (1H1,10X,38HSTABILITY CRITERIA --- M.O.C. REQUIRES,I3,
     154HADDITIONAL PARTICLE MOVES TO COMPLETE FLOW TIME STEP =,I3)
 6010 FORMAT (1H1,10X,42HTHE LIMITING STABILITY CRITERION IS CELDIS)
 6020 FORMAT (1H1,10X,40HTHE LIMITING STABILITY CRITERION IS BETA)
 6030 FORMAT (1H1,10X,58HTHE LIMITING STABILITY CRITERION IS MAXIMUM INJ
     1ECTION RATE//15X,35H MAX. INJECTION OCCURS IN CELL IX = ,I3,
     2 6H IY = ,I3)
      END
```

```
**** TSO FOREGROUND HARDCOPY ****
DSNAME=U11236C.KONIMOD.CNTL
                                                  (ISIP     )
C  USE META COMMANDS (BELOW) WHEN COMPILED ON MICROCOMPUTER
C  $NOFLOATCALLS
C  $STORAGE:2
      SUBROUTINE ISIP                                                   K  10
      DOUBLE PRECISION DMIN1,DABS,XI                                    K  20
      CHARACTER*8 TITLE                                                 K  21
      REAL*8 TMRX,VPRM,HI,HR,HC,HK,WT,REC,RECH,TIM,AOPT                 K  30
      REAL*8 XDEL,YDEL,S,AREA,SUMT,RHO,PARAM,TEST,TOL,PINT,HMIN,PYR     K  40
      REAL*8 DXINV,DYINV,ARINV,PORINV                                   K  50
      REAL*8 HJ                                                         K  55
      REAL*8 A,C,E,F,D,TBAR,COEF,CHK,QL,CH,GH,EH,FH,HH,ALF,BET,GAM,W    K  60
      INTEGER FCON                                                      K  61
      COMMON /PRMI/ NTIM,NPMP,NPNT,NITP,N,NX,NY,NP,NREC,INT,NNX,NNY,NUMO K  70
     1BS,NMOV,IMOV,NPMAX,ITMAX,NZCRIT,IPRNT,NPTPND,NPNTMV,NPNTVL,NPNTD,N K  80
     2PNCHV,NPDELC,ICHK,FCON,IHEAD,ISOLV                                K  90
      COMMON /PRMC/ NODEID(20,20),NPCELL(20,20),NPOLD(20,20),LIMBO(500), K 100
     1IXOBS(5),IYOBS(5)                                                 K 110
     2,NDECAY,NSORB                                                     K 120
      COMMON /HEDA/ THCK(20,20),PERM(20,20),TMWL(5,50),TMOBS(50),ANFCTR K 130
     1,THICK(20,20)                                                     K 140
      COMMON /HEDB/ TMRX(20,20,2),VPRM(20,20),HI(20,20),HR(20,20),HC(20, K 150
     120),HK(20,20),WT(20,20),REC(20,20),RECH(20,20),TIM(100),AOPT(20),T K 160
     2ITLE(10),XDEL,YDEL,S,AREA,SUMT,RHO,PARAM,TEST,TOL,PINT,HMIN,PYR   K 170
     3,HJ(20,20)                                                        K 180
      COMMON /BALM/ TOTLQ,TOTLQI,TPIN,TPOUT,TPQR                        K 190
      COMMON /XINV/ DXINV,DYINV,ARINV,PORINV                            K 200
      DIMENSION DEL(20,20),ETA(20,20),XI(20,20),V(20,20)                K 210
C     ***************************************************************** K 220
      LENGTH=10                                                         K 221
      KOUNT=0                                                           K 230
      PQIN = 0.0                                                        K 240
      PQOUT = 0.0                                                       K 250
      PQR = 0.0                                                         K 260
      I2=NX-2                                                           K 270
      J2=NY-2                                                           K 280
      DO 35 I=1,NX                                                      K 290
      DO 35 J=1,NY                                                      K 300
   35 HJ(I,J)=HK(I,J)                                                   K 310
C     ***************************************************************** K 320
C     ---TERMINATE PROGRAM -- ITMAX EXCEEDED---                         K 330
   40 IF (KOUNT.LE.ITMAX) GO TO 50                                      K 340
      WRITE (6,360)                                                     K 350
      DO 45 J=1,NY                                                      K 360
      DO 45 I=1,NX                                                      K 370
   45 HK(I,J)=HJ(I,J)                                                   K 380
      CALL OUTPT                                                        K 390
      STOP                                                              K 400
C     ***************************************************************** K 410
C     ---INITIALIZE DATA FOR A NEW ITERATION---                         K 420
   50 IF (MOD(KOUNT,LENGTH)) 60,60,70                                   K 430
   60 NTH=0                                                             K 440
   70 NTH=NTH+1                                                         K 450
      W=AOPT(NTH)                                                       K 460
      BIGI=0.0                                                          K 470
      TEST=0.0                                                          K 480
C     ***************************************************************** K 490
C     ---INITIALIZE SIP PARAMETERS---                                   K 500
      DO 80 I=1,NX                                                      K 510
      DO 80 J=1,NY                                                      K 520
      DEL(I,J)=0.                                                       K 530
      ETA(I,J)=0.                                                       K 540
      V(I,J)=0.                                                         K 550
   80 XI(I,J)=0.
      KOUNT=KOUNT+1
      RHO=S/TIM(N)
C     ************************************************************
C     ---CHOOSE SIP NORMAL OR REVERSE ALGORITHM---
      IF (MOD(KOUNT,2)) 100,240,100
  100 DO 210 J=2,NNY
      DO 210 I=2,NNX
      IF (THCK(I,J).EQ.O.) GO TO 210
      COEF=VPRM(I,J)
      QL=-COEF*WT(I,J)
      A=TMRX(I-1,J,1)*DXINV
      C=TMRX(I,J,1)*DXINV
      E=TMRX(I,J-1,2)*DYINV
      F=TMRX(I,J,2)*DYINV
      TBAR=-E-A-C-F-RHO-COEF
      HH=DEL(I,J-1)*E/(1.+W*DEL(I,J-1))
      GH=ETA(I-1,J)*A/(1.+W*ETA(I-1,J))
      EH=E-W*HH
      AH=A-W*GH
      TBARH=TBAR+W*HH+W*GH
      CH=C-W*HH
      FH=F-W*GH
      ALF=EH
      BET=AH
      GAM=TBARH-ALF*ETA(I,J-1)-BET*DEL(I-1,J)
      DEL(I,J)=CH/GAM
      ETA(I,J)=FH/GAM
      D=-A*HJ(I-1,J)-C*HJ(I+1,J)-F*HJ(I,J+1)-E*HJ(I,J-1)-TBAR*HJ(I,J)-
     1  RHO*HK(I,J)+QL+RECH(I,J)+REC(I,J)*ARINV
      V(I,J)=(D*1.00-ALF*V(I,J-1)-BET*V(I-1,J))/GAM
  210 CONTINUE
C     ************************************************************
C     ---BACK SUBSTITUTION FOR VECTOR XI---
      DO 220 I=1,I2
      I3=NX-I
      DO 220 J=1,J2
      J3=NY-J
      IF (THCK(I3,J3).EQ.0.0) GO TO 220
      XI(I3,J3)=V(I3,J3)-(DEL(I3,J3)*XI(I3+1,J3)+ETA(I3,J3)*XI(I3,J3+1))
  220 CONTINUE
C     ************************************************************
C     ---COMPUTE MAGNITUDE OF CHANGE WITH CLOSURE CRITERION---
      DO 230 J=2,NNY
      DO 230 I=2,NNX
      CHK=DABS(XI(I,J))
      IF (CHK.GT.BIGI) BIGI=CHK
      IF (BIGI.GT.TOL) TEST=1.
  230 HJ(I,J)=HJ(I,J)+XI(I,J)
      IF(TEST.EQ.1.0.AND.KOUNT.LT.ITMAX)GO TO 40
      GO TO 280
C     ************************************************************
C     ---SIP REVERSE ALGORITHM---
  240 DO 250 JJ=1,J2
      J=NY-JJ
      DO 250 I=2,NNX
      IF(THCK(I,J).EQ.0.0)GO TO 250
      COEF=VPRM(I,J)
      QL=-COEF*WT(I,J)
      A=TMRX(I-1,J,1)*DXINV
      C=TMRX(I,J,1)*DXINV
      E=TMRX(I,J-1,2)*DYINV
      F=TMRX(I,J,2)*DYINV
C     ************************************************************
C     ---COMPUTE INTERMEDIATE VECTORS-FORWARD SUBSTITUTION---
      TBAR=-E-A-C-F-RHO-COEF
      HH=DEL(I,J+1)*F/(1.+W*DEL(I,J+1))
      GH=ETA(I-1,J)*A/(1.+W*ETA(I-1,J))
      EH=F-W*HH
      AH=A-W*GH
      TBARH=TBAR+W*HH+W*GH
      CH=C-W*HH
      FH=E-W*GH
      ALF=EH
      BET=AH
      GAM=TBARH-ALF*ETA(I,J+1)-BET*DEL(I-1,J)
      DEL(I,J)=CH/GAM
      ETA(I,J)=FH/GAM
      D=-A*HJ(I-1,J)-C*HJ(I+1,J)-F*HJ(I,J+1)-E*HJ(I,J-1)-TBAR*HJ(I,J)-
     1  RHO*HK(I,J)+QL+RECH(I,J)+REC(I,J)*ARINV
      V(I,J)=(D*1.00-ALF*V(I,J+1)-BET*V(I-1,J))/GAM
  250 CONTINUE
C     *****************************************************************
C     ---BACKWARD SUBSTITUTION FOR VECTOR XI---
      DO 260 J3=2,NNY
      DO 260 I=1,I2
      I3=NX-I
      XI(I3,J3)=V(I3,J3)-(DEL(I3,J3)*XI(I3+1,J3)+ETA(I3,J3)*XI(I3,J3-1))
  260 CONTINUE
C     *****************************************************************
C     ---COMPARE MAGNITUDE OF CHANGE WITH CLOSURE CRITERION---
      DO 270 J=2,NNY
      DO 270 I=2,NNX
      CHK=DABS(XI(I,J))
      IF (CHK.GT.BIGI) BIGI=CHK
  270 HJ(I,J)=HJ(I,J)+XI(I,J)
      IF (BIGI.GT.TOL) TEST=1.
      IF(TEST.EQ.1.0.AND.KOUNT.LT.ITMAX) GO TO 40
  280 CONTINUE
      DO 300 J=1,NY
      DO 300 I=1,NX
      IF (THCK(I,J).EQ.0.0) GO TO 300
      HK(I,J)=HJ(I,J)
      IF (REC(I,J).GT.0.0) GO TO 232
      PQIN=PQIN+REC(I,J)
      GO TO 234
  232 PQOUT=PQOUT+REC(I,J)
  234 IF(RECH(I,J).GT.0.0) GO TO 236
      PQR=PQR + RECH(I,J)*AREA
      GO TO 238
  236 PQOUT=PQOUT+RECH(I,J)*AREA
  238 CONTINUE
C     *****************************************************************
C     ---COMPUTE LEAKANCE FOR MASS BALANCE---
      IF (VPRM(I,J).EQ.0.0) GO TO 300
      DELQ=-VPRM(I,J)*AREA*(WT(I,J)-HK(I,J))
      IF (DELQ.LE.0.0) GO TO 290
      TOTLQ=TOTLQ+DELQ*TIM(N)
      GO TO 300
  290 TOTLQI=TOTLQI+DELQ*TIM(N)
  300 CONTINUE
      TPIN=TPIN+PQIN*TIM(N)
      TPQR= TPQR+PQR*TIM(N)
      TPOUT=TPOUT+PQOUT*TIM(N)
C
      WRITE (6,370) N
      WRITE (6,390) KOUNT
C     *****************************************************************
      RETURN
C     *****************************************************************
  360 FORMAT (1H0,5X,64H***   EXECUTION TERMINATED -- MAX. NO. ITERATION
     1S EXCEEDED   ***/26X,21HFINAL OUTPUT FOLLOWS:)
```

```
370 FORMAT(1HO//3X,4HN = ,1I4)                                         K1880
390 FORMAT (1H ,2X,23HNUMBER OF ITERATIONS = ,1I4)                      K1890
400 FORMAT (1HO,10E12.7)                                                K1900
    END                                                                 K1910-
```

```
**** TSO FOREGROUND HARDCOPY ****
DSNAME=U11236C.KONIMOD.CNTL                         (GRPH     )

C  USE META COMMANDS (BELOW) WHEN COMPILED ON MICROCOMPUTER
C  $NOFLOATCALLS
C  $STORAGE:2
      SUBROUTINE GRPH
      CHARACTER*8 TITLE
      REAL*8 TMRX,VPRM,HI,HR,HC,HK,WT,REC,RECH,TIM,AOPT
      REAL*8 XDEL,YDEL,S,AREA,SUMT,RHO,PARAM,TEST,TOL,PINT,HMIN,PYR
      REAL*8 HJ
      INTEGER FCON
      COMMON /PRMI/ NTIM,NPMP,NPNT,NITP,N,NX,NY,NP,NREC,INT,NNX,NNY,NUMO
     1BS,NMOV,IMOV,NPMAX,ITMAX,NZCRIT,IPRNT,NPTPND,NPNTMV,NPNTVL,NPNTD,N
     2PNCHV,NPDELC,ICHK,FCON,IHEAD,ISOLV
      COMMON /HEDA/ THCK(20,20),PERM(20,20),TMWL(5,50),TMOBS(50),ANFCTR
     1,THICK(20,20)
      COMMON /HEDB/ TMRX(20,20,2),VPRM(20,20),HI(20,20),HR(20,20),HC(20,
     120),HK(20,20),WT(20,20),REC(20,20),RECH(20,20),TIM(100),AOPT(20),T
     2ITLE(10),XDEL,YDEL,S,AREA,SUMT,RHO,PARAM,TEST,TOL,PINT,HMIN,PYR
     3,HJ(20,20)
      COMMON /CHMA/ PART(3,3200),CONC(20,20),TMCN(5,50),VX(20,20),VY(20,
     120),CONINT(20,20),CNRECH(20,20),POROS,SUMTCH,BETA,TIMV,STORM,STORM
     2I,CMSIN,CMSOUT,FLMIN,FLMOT,SUMIO,CELDIS,DLTRAT,CSTORM
     3,DCYLAM,BLKDEN,SRBRAT,SRBSAT,SRBALF,VOLDCY,VOLSRB,SRBDCY
      REAL*8 IH(20)
      DIMENSION TRANS(20)
C     ****************************************************************
      TIMD=SUMT/86400.
      TIMY=SUMT/(86400.0*365.25)
C     ---PRINT HEAD MAP---
      WRITE (10,200) INT,N
      WRITE (10,210) INT,N,SUMT,TIMD,TIMY
      DO 20 IY=1,NY
      DO 20 IX=1,NX
      IH(IX)=HI(IX,IY) - HK(IX,IY) + 0.5
      TRANS(IX)=PERM(IX,IY)*THCK(IX,IY)
   20 WRITE (10,220) INT,N,IX,IY,
     1               HK(IX,IY),IH(IX),THCK(IX,IY),TRANS(IX),CONC(IX,IY)
C     ****************************************************************
      RETURN
C     ****************************************************************
  200 FORMAT (1H ,2I4)
  210 FORMAT (1H ,2I4,1P3E12.5)
  220 FORMAT (1H ,4I4,3F10.4,E10.2,F10.4)
      END
```

APPENDIX II

FORTRAN IV PROGRAM CHANGES

APPENDIX II-A

GLOBAL DECLARATIONS AND NAMED COMMON BLOCKS

Delete and insert the following Fortran statements to implement the modifications described in this report.

Global Declarations

Insert the following Fortran statements:

```
REAL*8 HJ
```

as lines:

A	117	D	34	G	45	J	45
B	61	E	55	H	35		
C	46	F	33	I	35		

```
CHARACTER*8 TITLE
```

as lines:

A	71	D	11	G	11	J	11
B	21	E	11	H	11		
C	11	F	11	I	11		

```
INTEGER FCON
```

as lines:

A	118	D	36	G	46	J	46
B	68	E	56	H	36		
C	51	F	36	I	36		

Named Common, PRMI

Delete:

A	141	D	61	G	71	J	70
B	91	E	81	H	61		
C	81	F	61	I	61		

Insert the Fortran statement:

```
2PNCHV,NPDELC,ICHK,FCON,IHEAD,ISOLV
```

as lines:

A	142	D	62	G	72	J	71
B	92	E	82	H	62		
C	82	F	62	I	62		

Named Common, HEDA

No deletions.

Insert the Fortran statement:

```
1,THICK(60,60)
```

as lines:

A	171	D	91	G	101	J	111
B	121	E	111	H	91		
C	111	F	91	I	91		

Named Common, HEDB

No deletions.

Insert the statement:

```
3,HJ(60,60)
```

as lines:

A	205	D	125	G	135	J	145
B	155	E	145	H	125		
C	145	F	125	I	125		

Named Common, BALM

Delete:

B	186	C	146	H	126

Insert the statement:

```
COMMON /BALM/ TOTLQ,TOTLQI,TPIN,TPOUT,TPQR
```

as lines:

B	187	C	147	H	127

APPENDIX II-B

STRONGLY IMPLICIT PROCEDURE

Main Program

To implement the subroutine ISIP the following lines were added to the Main program.

Insert:

A 436-A 439

Subroutine PARLOD

To add the subroutine ISIP, modifications to the subroutine PARLOD are indicated below.

Delete:

B2960
B3960-B3970

Insert:

B 211
B 212
B 465
B 585
B 586
B2872
B2902
B2951A-B2968B
B3891A
B3891B
B3965-B3975

SIP iteration parameters are calculated in lines B2952B through B2968B. Line B465 reads the values for all of the integer flags that have been added to implement the modifications described in this report.

APPENDIX II-C

TRANSMISSIVITY

Main Program

In this part of the program, updating of the transmissivities (for an unconfined aquifer) after every time step is performed by the changes indicated below.

Insert:

A 441A-A 450C

Subroutine PARLOD

Line B65 is replaced with line B67 to facilitate the declaration of flag TP as an integer. TP dictates whether the input is transmissivity the hydraulic conductivity. TP and FCON are also read in line B465 as stated in Appendix II-B.

All lines that have been deleted and added in subroutine PARLOD to incorporate transmissivity updating and either transmissivity or hydraulic conductivity input options are listed below.

Delete:

B 65
B2010
B2050-B2170
B2250
B1631-B1910

Insert:

B 67
B 465
B 588
B 589
B 971
B1491
B1611
B1632
B2011
B2021
B2252
B2254
B2271 -B2276
B2351A-B2359C
B3891D-B3891E

Subroutine OUTPT

This subroutine was modified as illustrated below to print the updated transmissivity and saturated thickness when an unconfined aquifer is being modeled.

Insert:

H 711-H 729
H1192-H1198

APPENDIX II-D

HYDRAULIC HEAD SIMULATION

Main Program

The changes made to the main program are indicated below.

Delete:

A 280 A 680

Insert:

A 281 A 452 A 615 A 681

Subroutine PARLOD

The flag IHEAD is read in line B465 as stated in Appendix II-B. Other changes are listed below.

Insert:

B 587 B3891C

APPENDIX II-E

MASS BALANCE

Subroutine PARLOD

Insert:

B 301

Subroutine ITERAT

The changes to this subroutine are listed below.

Delete:

C1187
C1210
C1215

Insert:

C 194
C1187A
C1211
C1216
C1232A

Subroutine OUTPT

The modifications made to in this subroutine for mass balance modifications are listed below.

Delete:

H 574
H 716
H 721
H 755
H1096
H1103

Insert:

H 501
H 575
H 730
H 740
H 757
H 766
H 841
H 887
H1095-H1110

APPENDIX II-F

SATURATED THICKNESS

Subroutine PARLOD

Line B65 is replaced with line B67 (as previously described in Appendix II-C) to facilitate the declaration of the integer flag BTM. BTM is also read in line B465 as stated in Appendix II-B. All changes made to PARLOD to incorporate the input of either saturated thickness or bottom elevation for an unconfined aquifer are listed below.

Delete:

B65 B1940 B2630-B2750

Insert:

B 67	B1942-B1944	B3162-B3168	B3891F
B465	B2041-B2146	B3435	B4212 -B4214
B589A			

APPENDIX II-G

ADDITIONAL MODIFICATIONS

Main Program

To implement the subroutine GRPH, the following lines were added to the main program.

Insert:

A 266
A 321
A 620
A 662-A 664
A 725

Subroutine PARLOD

Delete:

B2270
B3460
B3590
B3810
B3895

Insert:

B 212A
B 265
B 564-B 565
B 640
B 700
B 755
B 962-B 964
B1235
B1395
B2022
B2256
B2585
B2761-B2764
B3151
B3461
B3591
B3685
B3811
B3815
B3895
B3900
B3925
B3945
B4125
B4191-4192
B4525

Subroutine CHMOT

Insert:

I 344-I 349
I1125
I1295
I1535

APPENDIX III

DEFINITION OF SELECTED FORTRAN IV PROGRAM VARIABLES

BTM	An integer flag used to indicate low saturated thickness is input. For input of saturated thickness, BTM must equal zero. For input of bottom elevation, BTM must equal 1. BTM equals zero if FCON equals zero.
DEL	Two dimensional array used in the SIP normal and reverse algorithms for forward subsitution.
ETA	Two dimensional array used in the SIP normal and reverse algorithms for forward substitution.
FCON	An integer flag used to indicate the option of simulating confined or unconfined aquifer. For confined aquifer simulation, FCON must be equal to zero and for an unconfined aquifer simulation, FCON must be equal to 1.
HJ	A two dimensional array used for temporary storage of hydraulic head in subroutine ISIP (ft).
IHEAD	An integer flag used to indicate whether the simulation is only for hydraulic head or for solute transport. For only the hydraulic head simulation, IHEAD must be equal to 1 and for solute transport simulation, IHEAD must be equal to zero.
IORDER	Vector that indicates the order of the iteration parameters used in the SIP algorithm.
ISOLV	This is an integer flag used to implement the option for different solution algorithms for flow equation. To use ADIP algorithm, ISOLV must be equal to zero and for SIP algorithm, ISOLV must be equal to 1.
LENGTH	Number of iteration parameters in SIP algorithm.
PQR	Rate of recharge from the distributed source to the aquifer (ft^3/sec).
TEMP	Vector for arranging the SIP iteration parameters in geometric sequence.
THICK	A two dimensional array used in the main program to update aquifer thickness for unconfined aquifer (ft).
TP	TP is an integer flag to indicate the option of inputting the hydraulic conductivity or transmissivity as an input variable. For transmissivity, TP must be equal to zero and for hydraulic conductivity, TP must be equal to 1.
TPQR	Total amount of recharge to the aquifer from distributed sources during the simulation period (ft^3).
V	Two dimensional array used in SIP normal and reverse algorithms for forward substitution.

XI	Two dimensional array containing incremental head values in SIP solution, during backward substitution. If XI is less than or equal to the prespecified value for convergence, the iteration process will be stopped and the convergence is achieved (ft).
W	Iteration parameter used in SIP algorithm.

APPENDIX IV

ADDITIONAL DATA REQUIREMENTS

Five variables have been added for the modifications made to the NRC version of the USGS Solute Transport Model. These variables allow for (a) the choice of the iterative techniques to be used when solving the groundwater equation, (b) the type of simulation (transport or head only), (c) the type of aquifer, (d) the input of either transmissivity or hydraulic conductivity, and ((e) the input of either saturated thickness or bottom elevation for an uncontined aquifer. The data is contained on Data Card 5; the input formats are given in Appendix IV, page IV-5. The definition of the variables are:

ISOLV = 0 ADIP -- Alternating-Direction Implicit Procedure
= 1 SIP -- Strongly Implicit Procedure

IHEAD = 0 Transport simulation
= 1 Head only simulation

FCON = 0 Confined aquifer
= 1 Unconfined aquifer

TP = 0 Transmissivity input
= 1 Hydraulic Conductivity input

BTM = 0 Saturated Thickness input
= 1 Bottom Elevation input

APPENDIX V

DATA DEFINITIONS AND INPUT FORMATS

Card Image	Column	Format	Variable	Definition
1	1-80	10A8	TITLE	Description of problem
2	1- 4	I4	NTIM	Maximum number of time steps in a pumping period (limit=100)*.
	5- 8	I4	NPMP	Number of pumping periods. Note that if NPMP>1, then data set 10 must be completed. (limit=20)*.
	9-12	I4	NX	Number of nodes in x direction (limit=20)*.
	13-16	I4	NY	Number of nodes in y direction (limit=20)*.
	17-20	I4	NPMAX	Maximum number of particles (limit=3200)*.
	21-24	I4	NPNT	Time-step interval for printing hydraulic and chemical output data.
	25-28	I4	NITP	Number of iteration parameters (usually 4<=NITP<=7).
	29-32	I4	NUMOBS	Number of observation points to be specified in a following data set (limit=5)*.
	33-36	I4	ITMAX	Maximum allowable number of iterations in ADIP or SIP (usually 100 <=ITMAX<=200).
	37-40	I4	NREC	Number of pumping or injection wells to be specified in a following data set (limit=50)*.
	41-44	I4	NPTPND	Initial number of particles per node (options=4,5,8,9).
	45-48	I4	NCODES	Number of node identification codes to be specified in a following data set (limit=10)*.

Card Image	Column	Format	Variable	Definition
	49-52	I4	NPNTMV	Particle movement interval (IMOV) for printing chemical output data. (Specify 0 to print only at end of time steps).
	53-56	I4	NPNTVL	Option for printing computed velocities (0=do not print; 1=print for first time step; 2=print for all time steps).
	57-60	I4	NPNTD	Option for printing computed dispersion equation coefficients (option definition same as for NPNTVL).
	61-64	I4	NPDELC	Option for printing computed changes in concentration (0=do not print; 1=print).
	65-68	I4	NPNCHV	Option to punch velocity data (option definition same as for NPNTVL). When specified, program will punch on unit 7 the velocities at nodes.
3	1- 5	G5.0	PINT	Pumping period in years.
	6-10	G5.0	TOL	Convergence criteria in ADIP (usually TOL<=0.01).
	11-15	G5.0	POROS	Effective porosity.
	16-20	G5.0	BETA	Characteristic length, in feet (=longitudinal dispersivity).
	21-25	G5.0	S	Storage coefficient (set S=0 for steady flow problems).
	26-30	G5.0	TIMX	Time increment multiplier for transient flow problems. TIMX is disregarded if S=0.
	31-35	G5.0	TINIT	Size of initial time step in seconds. TINIT is disregarded if S=0.

Card Image	Column	Format	Variable	Definition
	36-40	G5.0	XDEL	Width of finite-difference cell in x direction, in feet.
	41-45	G5.0	YDEL	Width in finite-difference cell in y direction, in feet.
	46-50	G5.0	DLTRAT	Ratio of transverse to longitudinal dispersivity.
	51-55	G5.0	CELDIS	Maximum cell distance per particle move (value between 0 and 1.0).
	56-60	G5.0	ANFCTR	Ratio of Transmissivity tensors for anisotropic site (T(yy) to T(xx)).
4	1- 5	I5	NDECAY	If NDECAY=1 decay will be simulated, if NDECAY=0 decay will not be simulated.
	6-10	I5	NSORB	If NSORB=1 sorption will be simulated using a linear solver, if NSORB=2 sorption will be simulated using the Langmuir solver, if NSORB=3 sorption will be simulated using the Freundlich solver, if NSORB=0 sorption will not be simulated.
	11-20	F10.0	DCYTIM	If NDECAY=1, DCYTIM=decay half life, in years. If NDECAY=0, DCYTIM=0.
	21-30	F10.0	DENROCK	If NSORB=1,2, or 3, DENROCK=density of aquifer in gm/cm3. If NSORB=0, DENROC=0.
	31-40	F10.0	SORBQR	If NSORB=1,2, OR 3, SORBQR is the value of Kd, in ml/g. If NSORB=0, SORBQR=0.
	41-50	F10.0	SORBST	If NSORB=2, SORBST is the sorbtion saturation value for the Langmuir solver. If NSORB=0, 1, or 3, SORBST=0.

Card Image	Column	Format	Variable	Definition
	51-60	F10.0	SORBAL	If NSORB=3, SORBAL is the value of alpha for the Freundlich isotherm, if NSORB=0,1, or 2, SORBAL=0.
5	1- 4	I4	ISOLV	ISOLV=0 for ADIP algorithm and ISOLV=1 for SIP algorithm.
	5- 8	I4	IHEAD	IHEAD=0 for solute transport simulation. IHEAD=1 for only head simulation.
	9-12	I4	FCON	FCON=0 for confined aquifer simulation. FCON=1 for unconfined aquifer simulation.
	13-16	I4	TP	TP=1 for hydraulic conductivity input. TP=0 for transmissivity input.
	17-20	I4	BTM	BTM=1 for bottom elevation input (unconfined aquifer simulation). BTM=0 for saturated thickness input. (BTM=0 if FCON=0.)

See footnotes at end of table.

Data set	Number of card images	Format	Variable	Definition
1	Value of NUMOBS (limit=5)*	2I2	IXOBS, IYOBS	x and y coordinates of observation points. This data set is eliminated if NUMOBS is specified as =0.
2	Value of NREC (limit=50)*	2I2, 2G8.2	IX, IY, REC, CNRECH	x and y coordinates of pumping (+) or injection (-) wells, rate in ft 3/s, and if an injection well, the concentration of injected water. This data set is eliminated if NREC=0.
3	a. 1	I1, G10.0	INPUT, FCTR **	Parameter card for transmissivity or hydraulic conductivity. If TP=0, array for temporary storage of transmissivity data, in ft 2/s. If TP=1, array for temporary storage of hydraulic conductivity data, in ft/s. For an anisotropic aquifer, read in values of T(xx) and the program will adjust for anisotrophy by multiplying T(yy) by ANFCTR.
	b. Value of NY times the ceiling of NX/20 (limit=20)*	20G4.1	VPRM	

Data set	Number of card images	Format	Variable	Definition
4	a. 1	I1, G10.0	INPUT, FCTR **	
	b. Value of NY times the ceiling of NX/26 (limit=20)*	26G3.0	THCK	Parameter card for THICK. Saturated thickness or bottom elevation of aquifer, in feet. If BTM=0, array for storage of saturated thickness. If BTM=1, array for temporary storage of bottom elevation.
5	a. 1	I1, G10.0	INPUT, FCTR **	
	b. Value of NY times the ceiling of NX/20 (limit=20)*	20G4.0	WT	Parameter card for WT. Initial water-table or potentiometric elevation, or constant head in stream or source bed.
6	a. 1	I1, G10.0	INPUT, FCTR **	
	b. Value of NY times the ceiling of NX/20 (limit=20)*	20G4.1	RECH	Parameter card for RECH. Diffuse recharge (-) or discharge (+), in ft/s.
7	a. 1	I1, G10.0	INPUT, FCTR **	
	b. Value of NY (limit=20)*	60I1	NODEID	Parameter card for NODEID. Node identification matrix (used to define constant-head nodes or other boundary conditions and stresses).

Data set	Number of card images	Format	Variable	Definition
8	Value of NCODES (limit=10)*	I2, 3G10.2 I2	ICODE,FCTR1, FCTR2,FCTR3, OVERRD	Instructions for using NODEID array. When NODEID=ICODE, program sets leakance=FCTR1, CNRECH=FCTR2, and if OVERRD is nonzero, RECH=FCTR3. Set OVERRD=0 to preserve values of RECH specified in data set 5.
9	a. 1	I1, G10.0	INPUT,FCTR **	
	b. Value of NY times the ceiling of NX/20 (limit=20)*	20G4.0	CONC	Parameter card for CONC. Initial concentration in aquifer.
10				This data set allows time step parameters, print options, and pumpage data to be revised for each pumping period of the simulation. Data set 10 is only used if NPMP >1. The sequence of cards in data set 10 must be repeated (NPMP -1) times (that is, data set 10 is required for each pumping period after the first).

Data set	Number of card images	Format	Variable	Definition
	a.1	I1	ICHK	Parameter to check whether any revisions are desired. Set ICHK=1 if data are to be revised, and then complete data set 10b and c. Set ICHK=0 if data are not to be revised for the next pumping period, and skip rest of data set 10.
	b.1	10I4, 3G5.0	NTIM, NPNT, NITP, ITMAX, NREC, NPNTMV, NPNTVL, NPNTD, NPNDELC, NPNCHV, PINT, TIMX, TINIT	Thirteen parameters to be revised for next pumping period; the parameters were previously defined in the description of data cards 2 and 3. Only include this card if ICHK=1 in previous part a.
	c. Value of NREC ++ (limit=50)*	2I2, 2G8.2	IX, IY, REC, CNRECH	Revision of previously defined data set 2. Include part c only if ICHK=1 in previous part a and if NREC>0 in previous part b.

*These limits can be modified if necessary by changing the corresponding array dimensions in the COMMON statements of the program.

++Any wells set during one pumping period continue pumping and injecting during subsequent pumping periods unless the rates are explicitly reset in those subsequent periods.

**The parameter card must be the first card of the indicated data sets. It is used to specify whether the parameter is constant and uniform, and can be defined by one value, or whether it varies in space and must be defined at each node. If INPUT=0, the data set has a constant value, which is defined by FCTR. If INPUT=1, the data set is read from cards as described by part b. Then FCTR is a multiplication factor for the values read in the data set.

APPENDIX VI

UNITS SUMMARY TABLE

VARIABLE	FIELD UNITS	*	CONVERSION	=	MODEL UNITS
NTIM	-		-		(limit=100)+
NPMP	-		-		-
NX	-		-		(limit=60)+
NY	-		-		(limit=60)+
NPMAX	-		-		(limit=9850)+
NPNT	-		-		-
NITP	-		-		-
NUMOBS	-		-		(limit=5)+
ITMAX	-		-		-
NREC	-		-		-
NPTPND	-		-		-
NCODES	-		-		-
NPNTMV	-		-		-
NPNTVL	-		-		-
NPNTD	-		-		-
NPDELC	-		-		-
NPNCHV	-		-		-
PINT	yrs		-		yrs
TOL	-		-		-
POROS	-		-		-
BETA	-		-		-
S	percent		-		percent
TIMX	-		-		-
TINIT	sec		-		sec
XDEL	ft		-		ft
YDEL	ft		-		ft
DLTRAT	ratio		-		ratio
CELDIS	-		-		betw 0 & 1.0
ANFCTR	ratio		-		ratio
DCYTIM	yrs		-		yrs
DENROCK	gm/cm3		-		gm/cm3
SORBOR	ml/g		-		ml/g
SORBST	-		-		-
SORBAL	-		-		-
ISOLV	-		-		-
IHEAD	-		-		-
FCON	-		-		-
TP	-		-		-
IXOBS	-		-		-
IYOBS	-		-		-
IX	-		-		-
IY	-		-		-
REC	af/y		.001400463		ft3/s
CNRECH	mg/l		-		mg/l
VPRM					
TRANS	gpd/ft		1.54723 E-6		ft2/s
or PERM	gpd/ft2		1.54723 E-6		ft/s
THCK	ft		-		ft
WT	ft		-		ft

VARIABLE	FIELD UNITS	*	CONVERSION	=	MODEL UNITS
RECH	in/yr		26.7918 E-10		ft/s
NODEID	-		-		-
FCTR1	(gpd/ft2)/ft		1.54723 E-6		(ft/s)/ft
FCTR2	mg/l		-		mg/l
FCTR3	in/yr		26.7918 E-10		ft/s
OVERRD	-		-		-
CONC	mg/l		-		mg/l

*These limits may be modified by changing the corresponding array dimensions in the COMMON statements of the program.

APPENDIX VII

INPUT AND SELECTED OUTPUT FOR TEST PROBLEM 2

```
**** TSO FOREGROUND HARDCOPY ****
DSNAME=U11236D.EX3KB.CNTL

//M11236D JOB (?????,TSO-TR-KONI),KONIKOWRUN,
//  TIME=(0,40),CLASS=A,
//  MSGCLASS=X,NOTIFY=*
/*PASSWORD ????
/*JOBPARM ROOM=L
//*
//KONI EXEC PGM=KONI60G,REGION=1500K
//STEPLIB  DD DISP=SHR,DSN=U11236C.KONI.LOAD
//FT06F001 DD DSN=U11236D.EX3KB.OUTLIST,UNIT=STORAGE,
//             SPACE=(TRK,(10,10)),DISP=(MOD,CATLG),
//             DCB=(RECFM=VBA,LRECL=133,BLKSIZE=7448)
//FT10F001 DD DSN=U11236D.EX3KB.GRAPH,UNIT=STORAGE,
//             SPACE=(TRK,(10,10)),DISP=(MOD,CATLG),
//             DCB=(RECFM=FB,LRECL=80,BLKSIZE=7440)
//FT07F001 DD SYSOUT=B
//FT05F001 DD *
TEST PROBLEM 2 FOR TRANSIENT SIMULATION WITH SIP OPTION
  10  1     9  103200   1  10   2 100    1   9   2  10   1   0   0   0
  2.5 0.01    .3 100. .005     179.E5 900. 900.    .3   .5   1.
    0    0        0.         0.         0.         0.         0.
   1   0   0   0   0
 5 4
 5 7
 4 7       1.      0.0
0        0.1
0        20.
1          1
 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
 0.0100. 100. 100. 100. 100. 100. 100. 0.0
 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
 0.0 75.  75.  75.  75.  75.  75.  75.  0.0
 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
0         0.
1         1
000000000
022111220
000000000
000000000
000000000
000000000
000000000
000000000
022222220
000000000
  2        1.         0.         0. 0
  1        1.       100.         0. 0
0         0
```

```
U.S.G.S. METHOD-OF-CHARACTERISTICS MODEL FOR SOLUTE TRANSPORT IN GROUND WATER

TEST PROBLEM 2 FOR TRANSIENT SIMULATION WITH SIP OPTION

                 I N P U T    D A T A

                  GRID DESCRIPTORS

           NX     (NUMBER OF COLUMNS)  :      9
           NY     (NUMBER OF ROWS)     :     10
           XDEL   (X-DISTANCE IN FEET) :    900.0
           YDEL   (Y-DISTANCE IN FEET) :    900.0

                  TIME  PARAMETERS

           NTIM   (MAX. NO. OF TIME STEPS)          :      10
           NPMP   (NO. OF PUMPING PERIODS)          :       1
           PINT   (PUMPING PERIOD IN YEARS)         :       2.500
           TIMX   (TIME INCREMENT MULTIPLIER)       :       1.00
           TINIT  (INITIAL TIME STEP IN SEC.)       :  0.79E+07

             HYDROLOGIC AND CHEMICAL PARAMETERS

           S        (STORAGE COEFFICIENT)         :       0.005000
           POROS    (EFFECTIVE POROSITY)          :       0.30
           BETA     (CHARACTERISTIC LENGTH)       :     100.0
           DLTRAT   (RATIO OF TRANSVERSE TO
                    LONGITUDINAL DISPERSIVITY)    :       0.30
           ANFCTR   (RATIO OF T-YY TO T-XX)       :       1.000000

***NON-DECAYING SPECIES***

***NON-SORBING SPECIES***

***SIP USED***

***CONFINED AQUIFER***

                  EXECUTION PARAMETERS

           NITP    (NO. OF ITERATION PARAMETERS) :    10
           TOL     (CONVERGENCE CRITERIA - ADIP) :     0.0100
           ITMAX   (MAX.NO.OF ITERATIONS - ADIP) :   100
           CELDIS  (MAX.CELL DISTANCE PER MOVE
                      OF PARTICLES - M.O.C.)     :     0.500
           NPMAX   (MAX. NO. OF PARTICLES)       :  3200
           NPTPND  (NO. PARTICLES PER NODE)      :       9

                  PROGRAM OPTIONS

           NPNT    (TIME STEP INTERVAL FOR
                    COMPLETE PRINTOUT)       :     1
           NPNTMV  (MOVE INTERVAL FOR CHEM.
                    CONCENTRATION PRINTOUT)  :    10
           NPNTVL  (PRINT OPTION-VELOCITY
                    0=NO; 1=FIRST TIME STEP;
                    2=ALL TIME STEPS)        :     1
           NPNTD   (PRINT OPTION-DISP.COEF.
                    0=NO; 1=FIRST TIME STEP;
                    2=ALL TIME STEPS)        :     0
           NUMOBS  (NO. OF OBSERVATION WELLS
                    FOR HYDROGRAPH PRINTOUT) :     2
           NREC    (NO. OF PUMPING WELLS)    :     1

           NCODES  (FOR NODE IDENT.)         :     2
           NPNCHV  (PUNCH VELOCITIES)        :     0
           NPDELC  (PRINT OPT.-CONC. CHANGE) :     0
TIME INTERVALS (IN SECONDS)
   0.79000E+07 0.79000E+07 0.79000E+07 0.79000E+07 0.79000E+07 0.79000E+07 0.79000E+07 0.79000E+07 0.79000E+07 0.79000E+07
   0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00
   0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00
   0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00
   0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00
   0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00
   0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00
   0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00
   0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00
   0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00

         LOCATION OF OBSERVATION WELLS

              NO.      X     Y

               1       5     4
               2       5     7

         LOCATION  OF  PUMPING  WELLS

         X    Y    RATE(IN CFS)    CONC.

         4    7    0.100E+01        0.00

         AREA OF ONE CELL =   8.1000E+05

         X-Y SPACING:
             900.00
             900.00
```

```
AQUIFER THICKNESS (FT)
    0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
    0.0 20.0 20.0 20.0 20.0 20.0 20.0 20.0  0.0
    0.0 20.0 20.0 20.0 20.0 20.0 20.0 20.0  0.0
    0.0 20.0 20.0 20.0 20.0 20.0 20.0 20.0  0.0
    0.0 20.0 20.0 20.0 20.0 20.0 20.0 20.0  0.0
    0.0 20.0 20.0 20.0 20.0 20.0 20.0 20.0  0.0
    0.0 20.0 20.0 20.0 20.0 20.0 20.0 20.0  0.0
    0.0 20.0 20.0 20.0 20.0 20.0 20.0 20.0  0.0
    0.0 20.0 20.0 20.0 20.0 20.0 20.0 20.0  0.0
    0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0


 WATER TABLE
    0.    0.    0.    0.    0.    0.    0.    0.    0.
    0.  100.  100.  100.  100.  100.  100.  100.    0.
    0.    0.    0.    0.    0.    0.    0.    0.    0.
    0.    0.    0.    0.    0.    0.    0.    0.    0.
    0.    0.    0.    0.    0.    0.    0.    0.    0.
    0.    0.    0.    0.    0.    0.    0.    0.    0.
    0.    0.    0.    0.    0.    0.    0.    0.    0.
    0.    0.    0.    0.    0.    0.    0.    0.    0.
    0.   75.   75.   75.   75.   75.   75.   75.    0.
    0.    0.    0.    0.    0.    0.    0.    0.    0.


 TRANSMISSIVITY MAP (FT*FT/SEC)
   0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00
   0.00E+00  1.00E-01  1.00E-01  1.00E-01  1.00E-01  1.00E-01  1.00E-01  1.00E-01  0.00E+00
   0.00E+00  1.00E-01  1.00E-01  1.00E-01  1.00E-01  1.00E-01  1.00E-01  1.00E-01  0.00E+00
   0.00E+00  1.00E-01  1.00E-01  1.00E-01  1.00E-01  1.00E-01  1.00E-01  1.00E-01  0.00E+00
   0.00E+00  1.00E-01  1.00E-01  1.00E-01  1.00E-01  1.00E-01  1.00E-01  1.00E-01  0.00E+00
   0.00E+00  1.00E-01  1.00E-01  1.00E-01  1.00E-01  1.00E-01  1.00E-01  1.00E-01  0.00E+00
   0.00E+00  1.00E-01  1.00E-01  1.00E-01  1.00E-01  1.00E-01  1.00E-01  1.00E-01  0.00E+00
   0.00E+00  1.00E-01  1.00E-01  1.00E-01  1.00E-01  1.00E-01  1.00E-01  1.00E-01  0.00E+00
   0.00E+00  1.00E-01  1.00E-01  1.00E-01  1.00E-01  1.00E-01  1.00E-01  1.00E-01  0.00E+00
   0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00


 PERMEABILTY MAP (FT/SEC)
   0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00
   0.00E+00  5.00E-03  5.00E-03  5.00E-03  5.00E-03  5.00E-03  5.00E-03  5.00E-03  0.00E+00
   0.00E+00  5.00E-03  5.00E-03  5.00E-03  5.00E-03  5.00E-03  5.00E-03  5.00E-03  0.00E+00
   0.00E+00  5.00E-03  5.00E-03  5.00E-03  5.00E-03  5.00E-03  5.00E-03  5.00E-03  0.00E+00
   0.00E+00  5.00E-03  5.00E-03  5.00E-03  5.00E-03  5.00E-03  5.00E-03  5.00E-03  0.00E+00
   0.00E+00  5.00E-03  5.00E-03  5.00E-03  5.00E-03  5.00E-03  5.00E-03  5.00E-03  0.00E+00
   0.00E+00  5.00E-03  5.00E-03  5.00E-03  5.00E-03  5.00E-03  5.00E-03  5.00E-03  0.00E+00
   0.00E+00  5.00E-03  5.00E-03  5.00E-03  5.00E-03  5.00E-03  5.00E-03  5.00E-03  0.00E+00
   0.00E+00  5.00E-03  5.00E-03  5.00E-03  5.00E-03  5.00E-03  5.00E-03  5.00E-03  0.00E+00
   0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00


          NO. OF FINITE-DIFFERENCE CELLS IN AQUIFER =    56

          AREA OF AQUIFER IN MODEL  =  4.53800E+07 SQ. FT.


          NZCRIT   (MAX. NO. OF CELLS THAT CAN BE VOID OF
                    PARTICLES;  IF EXCEEDED, PARTICLES ARE REGENERATED)   =    1


 DIFFUSE RECHARGE AND DISCHARGE (FT/SEC)
   0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00
   0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00
   0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00
   0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00
   0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00
   0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00
   0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00
   0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00
   0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00
   0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00
```

```
NODE IDENTIFICATION MAP

    0    0    0    0    0    0    0    0    0
    0    2    2    1    1    1    2    2    0
    0    0    0    0    0    0    0    0    0
    0    0    0    0    0    0    0    0    0
    0    0    0    0    0    0    0    0    0
    0    0    0    0    0    0    0    0    0
    0    0    0    0    0    0    0    0    0
    0    0    0    0    0    0    0    0    0
    0    2    2    2    2    2    2    2    0
    0    0    0    0    0    0    0    0    0

  NO. OF NODE IDENT. CODES SPECIFIED :  2

        THE FOLLOWING ASSIGNMENTS HAVE BEEN MADE:
 CODE NO        LEAKANCE       SOURCE CONC.        RECHARGE

     2          1.000E+00       0.000E+00

     1          1.000E+00       1.000E+02
```

```
VERTICAL PERMEABILITY/THICKNESS (FT/(FT*SEC))
  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00
  0.00E+00  1.00E+00  1.00E+00  1.00E+00  1.00E+00  1.00E+00  1.00E+00  1.00E+00  0.00E+00
  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00
  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00
  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00
  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00
  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00
  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00
  0.00E+00  1.00E+00  1.00E+00  1.00E+00  1.00E+00  1.00E+00  1.00E+00  1.00E+00  0.00E+00
  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00
```

```
HEAD DISTRIBUTION - ROW
NUMBER OF TIME STEPS :      0
       TIME(SECONDS) :  0.00000E+00
       TIME(DAYS)    :  0.00000E+00
       TIME(YEARS)   :  0.00000E+00

   0.0000000    0.0000000    0.0000000    0.0000000    0.0000000    0.0000000    0.0000000    0.0000000    0.0000000

   0.0000000  100.0000000  100.0000000  100.0000000  100.0000000  100.0000000  100.0000000  100.0000000    0.0000000

   0.0000000    0.0000000    0.0000000    0.0000000    0.0000000    0.0000000    0.0000000    0.0000000    0.0000000

   0.0000000    0.0000000    0.0000000    0.0000000    0.0000000    0.0000000    0.0000000    0.0000000    0.0000000

   0.0000000    0.0000000    0.0000000    0.0000000    0.0000000    0.0000000    0.0000000    0.0000000    0.0000000

   0.0000000    0.0000000    0.0000000    0.0000000    0.0000000    0.0000000    0.0000000    0.0000000    0.0000000

   0.0000000    0.0000000    0.0000000    0.0000000    0.0000000    0.0000000    0.0000000    0.0000000    0.0000000

   0.0000000    0.0000000    0.0000000    0.0000000    0.0000000    0.0000000    0.0000000    0.0000000    0.0000000

   0.0000000   75.0000000   75.0000000   75.0000000   75.0000000   75.0000000   75.0000000   75.0000000    0.0000000

   0.0000000    0.0000000    0.0000000    0.0000000    0.0000000    0.0000000    0.0000000    0.0000000    0.0000000
```

```
ITERATION PARAMETERS
   9.823E-01 9.823E-01 9.515E-01 9.515E-01 8.870E-01 8.870E-01 6.353E-01 6.353E-01 0.000E+00 0.000E+00
   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
```

```
CONCENTRATION

NUMBER OF TIME STEPS :       0
       TIME(SECONDS) :   0.00000E+00
  CHEM.TIME(SECONDS) :   0.00000E+00
  CHEM.TIME(DAYS)    :   0.00000E+00
       TIME(YEARS)   :   0.00000E+00
  CHEM.TIME(YEARS)   :   0.00000E+00
 NO. MOVES COMPLETED :       0

    0.0000    0.0000    0.0000    0.0000    0.0000    0.0000    0.0000    0.0000    0.0000

    0.0000    0.0000    0.0000    0.0000    0.0000    0.0000    0.0000    0.0000    0.0000

    0.0000    0.0000    0.0000    0.0000    0.0000    0.0000    0.0000    0.0000    0.0000

    0.0000    0.0000    0.0000    0.0000    0.0000    0.0000    0.0000    0.0000    0.0000

    0.0000    0.0000    0.0000    0.0000    0.0000    0.0000    0.0000    0.0000    0.0000

    0.0000    0.0000    0.0000    0.0000    0.0000    0.0000    0.0000    0.0000    0.0000

    0.0000    0.0000    0.0000    0.0000    0.0000    0.0000    0.0000    0.0000    0.0000

    0.0000    0.0000    0.0000    0.0000    0.0000    0.0000    0.0000    0.0000    0.0000

    0.0000    0.0000    0.0000    0.0000    0.0000    0.0000    0.0000    0.0000    0.0000

    0.0000    0.0000    0.0000    0.0000    0.0000    0.0000    0.0000    0.0000    0.0000


CONCENTRATION

NUMBER OF TIME STEPS :       0

    0    0    0    0    0    0    0    0    0

    0    0    0    0    0    0    0    0    0

    0    0    0    0    0    0    0    0    0

    0    0    0    0    0    0    0    0    0

    0    0    0    0    0    0    0    0    0

    0    0    0    0    0    0    0    0    0

    0    0    0    0    0    0    0    0    0

    0    0    0    0    0    0    0    0    0

    0    0    0    0    0    0    0    0    0

    0    0    0    0    0    0    0    0    0


  N :      1
  NUMBER OF ITERATIONS :     6


HEAD DISTRIBUTION - ROW
NUMBER OF TIME STEPS :       1
       TIME(SECONDS) :   7.90000E+06
       TIME(DAYS)    :   9.14352E+01
       TIME(YEARS)   :   2.50338E-01

   0.0000000   0.0000000   0.0000000   0.0000000   0.0000000   0.0000000   0.0000000   0.0000000   0.0000000

   0.0000000  99.9999993  99.9999993  99.9999993  99.9999993  99.9999993  99.9999994  99.9999994   0.0000000

   0.0000000  94.5962333  94.5921494  94.6040241  94.6522037  94.7161106  94.7707524  94.8010807   0.0000000

   0.0000000  89.6822166  89.6535081  89.6564179  89.7728021  89.9259401  90.0508167  90.1179754   0.0000000

   0.0000000  85.2561563  85.1424281  85.0543364  85.3160963  85.6245042  85.8503762  85.9641867   0.0000000

   0.0000000  81.3804846  81.0423064  80.5374399  81.2508916  81.8449370  82.2026432  82.3853943   0.0000000

   0.0000000  78.2614423  77.5234648  75.2173956  77.7201288  78.7231459  79.1717111  79.3517008   0.0000000

   0.0000000  76.2808209  75.9720803  75.4729042  76.0806988  76.5588990  76.8154402  76.9244851   0.0000000

   0 0000000  75.0000002  75.0000001  75.0000001  75.0000001  75.0000002  75.0000002  75.0000002   0.0000000

   0.0000000   0.0000000   0.0000000   0.0000000   0.0000000   0.0000000   0.0000000   0.0000000   0.0000000
```

```
HEAD DISTRIBUTION - ROW
NUMBER OF TIME STEPS :       1
      TIME(SECONDS) :  7.90000E+06
      TIME(DAYS)    :  9.14352E+01
  >   TIME(YEARS)   :  2.50338E-01

  0    0    0    0    0    0    0    0    0

  0  100  100  100  100  100  100  100    0

  0   95   95   95   95   95   95   95    0

  0   90   90   90   90   90   90   93    0

  0   35   85   85   85   86   86   86    0

  0   81   81   81   81   82   82   82    c

  0   78   78   75   78   79   79   79    0

  c   76   78   75   76   77   77   77    0

  c   75   75   75   75   75   75   75    0

  0    0    0    0    0    0    0    0    0


DRAWDOWN
       0     0     0     0     0     0     0     0     0
       0     0     0     0     0     0     0     0     0
       0   -94   -94   -94   -94   -94   -94   -94     0
       0   -89   -89   -89   -89   -89   -89   -89     0
       0   -84   -84   -84   -84   -85   -85   -85     0
       0   -80   -80   -80   -80   -81   -81   -81     0
       0   -77   -77   -74   -77   -78   -78   -78     0
       0   -75   -75   -74   -75   -76   -76   -76     0
       0     0     0     0     0     0     0     0     0
       0     0     0     0     0     0     0     0     0
  CUMULATIVE MASS BALANCE -- (IN FT**3)

   RECHARGE                       :  0.00000E+00
   INJECTION                      :  0.00000E+00
   PUMPAGE                        :  7.90000E+06
   CUMULATIVE  NET  PUMPAGE       :  7.90000E+06
   WATER RELEASE FROM STORAGE     : -1.43390E+07
   LEAKAGE INTO AQUIFER           : -2.94414E+07
   LEAKAGE OUT OF AQUIFER         :  7.20111E+06
   CUMULATIVE  NET  LEAKAGE       : -2.22403E+07

        MASS BALANCE RESIDUAL     :  1.29500E+03
        ERROR  (AS PERCENT)       :  8.58178E-03

  RATE MASS BALANCE -- (IN C.F.S.)

   RECHARGE                       :  0.00000E+00
   LEAKAGE INTO AQUIFER           :  3.72877E+00
   LEAKAGE OUT OF AQUIFER         : -9.11533E-01
   NET LEAKAGE     (QNET)         :  2.81523E+00
   INJECTION                      :  0.00000E+00
   PUMPAGE                        :  1.00000E+00
   NET WITHDRAWAL   (TPUM)        :  1.00000E+00


  CONCENTRATION

  NUMBER OF TIME STEPS :       1
         DELTA T       :  7.90000E+06
         TIME(SECONDS) :  7.90000E+06
    CHEM.TIME(SECONDS) :  7.90000E+06
    CHEM.TIME(DAYS)    :  9.14352E+01
         TIME(YEARS)   :  2.50338E-01
    CHEM.TIME(YEARS)   :  2.50338E-01
   NO. MOVES COMPLETED :       2

     0.0000    0.0000    0.0000    0.0000    0.0000    0.0000    0.0000    0.0000    0.0000

     0.0000    0.0000    0.3207   66.7791   66.6826   65.6617    0.3076    0.0000    0.0000

     0.0000    0.0000    0.2206   31.7841   31.6633   24.7013    0.1576    0.0000    0.0000

     0.0000    0.0000   -0.0000    0.7066    0.6842    0.5092   -0.0037    0.0000    0.0000

     0.0000    0.0000    0.0000    0.0000    0.0000    0.0000    0.0000    0.0000    0.0000

     0.0000    0.0000    0.0000    0.0000    0.0000    0.0000    0.0000    0.0000    0.0000

     0.0000    0.0000    0.0000    0.0000    0.0000    0.0000    0.0000    0.0000    0.0000

     0.0000    0.0000    0.0000    0.0000    0.0000    0.0000    0.0000    0.0000    0.0000

     0.0000    0.0000    0.0000    0.0000    0.0000    0.0000    0.0000    0.0000    0.0000

     0.0000    0.0000    0.0000    0.0000    0.0000    0.0000    0.0000    0.0000    0.0000
```

```
CONCENTRATION

NUMBER OF TIME STEPS :      1

    0    0    0    0    0    0    0    0    0

    0    0    0   67   67   66    0    0    0

    0    0    0   32   32   25    0    0    0

    0    0    0    1    1    1    0    0    0

    0    0    0    0    0    0    0    0    0

    0    0    0    0    0    0    0    0    0

    0    0    0    0    0    0    0    0    0

    0    0    0    0    0    0    0    0    0

    0    0    0    0    0    0    0    0    0

    0    0    0    0    0    0    0    0    0

CHEMICAL MASS BALANCE

       MASS IN BOUNDARIES        :   1.26608E+09
       MASS OUT BOUNDARIES       :   0.00000E+00
       MASS PUMPED IN            :   0.00000E+00
       MASS PUMPED OUT           :   0.00000E+00
       INFLOW MINUS OUTFLOW      :   1.26608E+09
       INITIAL MASS STORED       :   0.00000E+00
       PRESENT MASS STORED       :   1.41025E+09
       CHANGE MASS STORED        :   1.41025E+09
     COMPARE RESIDUAL WITH NET FLUX AND MASS ACCUMULATION:
       MASS BALANCE RESIDUAL     :  -1.44168E+08
       ERROR  (AS PERCENT)       :  -1.13870E+01


  N :    10
  NUMBER OF ITERATIONS :      1


HEAD DISTRIBUTION - ROW
NUMBER OF TIME STEPS :      10
       TIME(SECONDS) :  7.88940E+07
       TIME(DAYS)    :  9.13125E+02
       TIME(YEARS)   :  2.50000E+00

   0.0000000   0.0000000   0.0000000   0.0000000   0.0000000   0.0000000   0.0000000   0.0000000   0.0000000

   0.0000000  99.9999995  99.9999996  99.9999995  99.9999995  99.9999995  99.9999995  99.9999985   0.0000000

   0.0000000  95.9387927  95.9347060  95.9488781  95.9958856  96.0611524  96.1171439  96.1482856   0.0000000

   0.0000000  91.8818727  91.8831837  91.8869210  91.9755132  92.1318802  92.2591281  92.3277433   0.0000000

   0.0000000  87.8530717  87.7383181  87.8621369  87.9178663  88.2205270  88.4600449  88.5758083   0.0000000

   0.0000000  83.9382272  83.5986963  83.0946532  83.8124858  84.4128187  84.7747183  84.9398308   0.0000000

   0.0000000  80.3627136  79.6233898  77.3150916  79.8248072  80.8338369  81.2863809  81.4883872   0.0000000

   0.0000000  77.5265238  77.2168575  76.7175182  77.3361156  77.8101366  78.0889025  78.1780800   0.0000000

   0.0000000  75.0000003  75.0000003  75.0000002  75.0000003  75.0000003  75.0000004  75.0000004   0.0000000

   0.0000000   0.0000000   0.0000000   0.0000000   0.0000000   0.0000000   0.0000000   0.0000000   0.0000000


  HEAD DISTRIBUTION - ROW
  NUMBER OF TIME STEPS :      10
         TIME(SECONDS) :  7.88940E+07
         TIME(DAYS)    :  9.13125E+02
         TIME(YEARS)   :  2.50000E+00

    0    0    0    0    0    0    0    0    0

    0  100  100  100  100  100  100  100    0

    0   96   96   96   96   96   96   96    0

    0   92   92   92   92   92   92   92    0

    0   88   88   88   88   88   88   88    0

    0   84   84   83   84   84   85   85    0

    0   80   80   77   80   81   81   81    0

    0   78   77   77   77   78   78   78    0

    0   75   75   75   75   75   75   75    0

    0    0    0    0    0    0    0    0    0
```

```
DRAWDOWN
     0     0     0     0     0     0     0     0     0
     0     0     0     0     0     0     0     0     0
     0   -95   -95   -95   -95   -95   -95   -95     0
     0   -91   -91   -91   -91   -91   -91   -91     0
     0   -87   -87   -87   -87   -87   -87   -88     0
     0   -83   -83   -82   -83   -83   -84   -84     0
     0   -79   -79   -78   -79   -80   -80   -80     0
     0   -77   -76   -76   -76   -77   -77   -77     0
     0     0     0     0     0     0     0     0     0
     0     0     0     0     0     0     0     0     0

  CUMULATIVE MASS BALANCE -- (IN FT**3)

   RECHARGE                    :  0.00000E+00
   INJECTION                   :  0.00000E+00
   PUMPAGE                     :  7.88940E+07
   CUMULATIVE  NET  PUMPAGE    :  7.88940E+07
   WATER RELEASE FROM STORAGE  : -1.46812E+07
   LEAKAGE INTO AQUIFER        : -2.27383E+08
   LEAKAGE OUT OF AQUIFER      :  1.33785E+08
   CUMULATIVE  NET  LEAKAGE    : -9.35883E+07

       MASS BALANCE RESIDUAL   :  1.30240E+04
       ERROR  (AS PERCENT)     :  6.12330E-03

  RATE MASS BALANCE -- (IN C.F.S.)

   RECHARGE                    :  0.00000E+00
   LEAKAGE INTO AQUIFER        :  2.78571E+00
   LEAKAGE OUT OF AQUIFER      : -1.78571E+00
   NET LEAKAGE      (QNET)     :  9.99994E-01
   INJECTION                   :  0.00000E+00
   PUMPAGE                     :  1.00000E+00
   NET WITHDRAWAL    (TPUM)    :  1.00000E+00
```

```
CONCENTRATION

NUMBER OF TIME STEPS :     10
       DELTA T       :  7.78400E+06
       TIME(SECONDS) :  7.88940E+07
  CHEM.TIME(SECONDS) :  7.88940E+07
  CHEM.TIME(DAYS)    :  9.13125E+02
       TIME(YEARS)   :  2.50000E+00
  CHEM.TIME(YEARS)   :  2.50000E+00
 NO. MOVES COMPLETED :      2

    0.0000    0.0000    0.0000    0.0000    0.0000    0.0000    0.0000    0.0000    0.0000

    0.0000    0.0339    1.7405   98.1823   99.8574   98.2215    1.7682    0.0341    0.0000

    0.0000    0.1000    3.6902   96.0881   99.6332   96.6284    3.3182    0.0902    0.0000

    0.0000    0.2534    6.3141   93.0406   98.9330   93.4149    6.4627    0.2830    0.0000

    0.0000    0.4882    8.9285   89.1229   96.9711   88.8627    8.8431    0.5052    0.0000

    0.0000    0.7073   10.7761   83.2644   90.4337   69.7606    9.8259    0.6730    0.0000

    0.0000    0.7472    8.0419   56.2821   74.6076   40.4176    8.3984    0.6589    0.0000

    0.0000    0.4182    3.3516   26.9020   41.5722   22.9543    4.6635    0.3921    0.0000

    0.0000    0.0645    0.2868    1.6677    6.9979    5.5293    0.7113    0.0755    0.0000

    0.0000    0.0000    0.0000    0.0000    0.0000    0.0000    0.0000    0.0000    0.0000
```

```
CONCENTRATION

NUMBER OF TIME STEPS =      10

     0     0     0     0     0     0     0     0     0

     0     0     2    98   100    98     2     0     0

     0     0     4    96   100    97     3     0     0

     0     0     6    93    99    93     6     0     0

     0     0     9    89    97    89     9     1     0

     0     1    11    83    90    70    10     1     0

     0     1     8    56    75    40     8     1     0

     0     0     3    27    42    23     5     0     0

     0     0     0     2     7     7     1     0     0

     0     0     0     0     0     0     0     0     0

CHEMICAL MASS BALANCE

        MASS IN BOUNDARIES       =  9.78987E+08
        MASS OUT BOUNDARIES      = -3.05349E+07
        MASS PUMPED IN           =  0.00000E+00
        MASS PUMPED OUT          = -1.34451E+08
        INFLOW MINUS OUTFLOW     =  8.41482E+08
        INITIAL MASS STORED      =  0.00000E+00
        PRESENT MASS STORED      =  8.56800E+08
        CHANGE MASS STORED       =  8.56800E+08
      COMPARE RESIDUAL WITH NET FLUX AND MASS ACCUMULATION:
        MASS BALANCE RESIDUAL    = -1.53178E+07
        ERROR  (AS PERCENT)      = -1.56466E+00
```

```
TEST PROBLEM 2 FOR TRANSIENT SIMULATION WITH SIP OPTION

     TIME VERSUS HEAD AND CONCENTRATION AT SELECTED OBSERVATION POINTS
             PUMPING PERIOD NO.     1


               TRANSIENT  SOLUTION


                    OBS.WELL NO.     X     Y                 N      HEAD (FT)    CONC.(MG/L)    TIME (YEARS)
                         1           5     4

                                                             0         0.0           0.0           0.000
                                                             1        89.8           0.7           0.250
                                                             2        91.9           3.2           0.501
                                                             3        92.0          40.4           0.751
                                                             4        92.0          70.7           1.001
                                                             5        92.0          81.2           1.252
                                                             6        92.0          91.1           1.502
                                                             7        92.0          95.5           1.752
                                                             8        92.0          96.9           2.003
                                                             9        92.0          98.1           2.253
                                                            10        92.0          98.9           2.500
                    OBS.WELL NO.     X     Y                 N      HEAD (FT)    CONC.(MG/L)    TIME (YEARS)
                         2           5     7

                                                             0         0.0           0.0           0.000
                                                             1        77.7           0.0           0.250
                                                             2        79.8           0.0           0.501
                                                             3        79.8           0.0           0.751
                                                             4        79.8           0.3           1.001
                                                             5        79.8           2.0           1.252
                                                             6        79.8           7.7           1.502
                                                             7        79.8          23.8           1.752
                                                             8        79.8          43.9           2.003
                                                             9        79.8          64.7           2.253
                                                            10        79.8          74.6           2.500
```

APPENDIX VIII

INPUT AND SELECTED OUTPUT FOR TEST PROBLEM 3

```
**** TSO FOREGROUND HARDCOPY ****
DSNAME=U11236D.EXNRC.CNTL

//M11236D JOB (?,TSO-TR-KONI),KONIKOWRUN,
//  TIME=(0,40),CLASS=A,
//  MSGCLASS=X,NOTIFY=*
/*PASSWORD ????
/*JOBPARM ROOM=L
//*
//KONI EXEC PGM=KONI60G,REGION=1500K
//STEPLIB  DD DISP=SHR,DSN=U11236C.KONI.LOAD
//FT06F001 DD DSN=U11236C.EXNRC.OUTLIST,UNIT=STORAGE,
//            SPACE=(TRK,(10,10)),DISP=(MOD,CATLG),
//            DCB=(RECFM=VBA,LRECL=133,BLKSIZE=7448)
//FT10F001 DD DSN=U11236C.EXNRC.GRAPH,UNIT=STORAGE,
//            SPACE=(TRK,(10,10)),DISP=(MOD,CATLG),
//            DCB=(RECFM=FB,LRECL=80,BLKSIZE=7440)
//FT07F001 DD SYSOUT=B
//FT05F001 DD *
TEST PROBLEM 3 FOR TRANSIENT SIMULATION WITH SIP OPTION
  10    1  20    33200    2   10    2 100    2    9    1   10    1    0    0    0
   4. 0.01  0.1 100..0005     113.E6  30.  30.    .3    .2     1
    1    1         33.      2.404         10.
   1    0    0    0    0
 4 2
 6 2
 3 2  -.0075     500.
17 2  0.0075      0.0
1         1
 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
 0.0 .03 .03 .03 .03 .03 .03 .03 .03 .03 .03 .03 .03 .03 .03 .03 .03 .03 .03 0.0
 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
1         1
0.00.00.00.00.00.00.00.00.00.00.00.00.00.00.00.00.00.00.00.0
0.050.50.50.50.50.50.50.50.50.50.50.50.50.50.50.50.50.50.0.0
0.00.00.00.00.00.00.00.00.00.00.00.00.00.00.00.00.00.00.00.0
1         1
 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
 0.0 14. 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 10. 0.0
 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
0        0.0
1         1
00000000000000000000
01000000000000000010
00000000000000000000
 1        0.3        .00          0. 0
0         0
```

```
U.S.G.S. METHOD-OF-CHARACTERISTICS MODEL FOR SOLUTE TRANSPORT IN GROUND WATER

TEST PROBLEM 3 FOR TRANSIENT SIMULATION WITH SIP OPTION

                   I N P U T    D A T A

                    GRID DESCRIPTORS

          NX     (NUMBER OF COLUMNS)  :     20
          NY     (NUMBER OF ROWS)     :      3
          XDEL   (X-DISTANCE IN FEET) :     30.0
          YDEL   (Y-DISTANCE IN FEET) :     30.0

                    TIME  PARAMETERS

          NTIM    (MAX. NO. OF TIME STEPS)          :       10
          NPMP    (NO. OF PUMPING PERIODS)          :        1
          PINT    (PUMPING PERIOD IN YEARS)         :        4.000
          TIMX    (TIME INCREMENT MULTIPLIER)       :        1.00
          TINIT   (INITIAL TIME STEP IN SEC.)       :   0.13E+08

            HYDROLOGIC AND CHEMICAL PARAMETERS

          S         (STORAGE COEFFICIENT)          :       0.000500
          POROS     (EFFECTIVE POROSITY)           :       0.10
          BETA      (CHARACTERISTIC LENGTH)        :     100.0
          DLTRAT    (RATIO OF TRANSVERSE TO
                    LONGITUDINAL DISPERSIVITY)     :       0.30
          ANFCTR    (RATIO OF T-YY TO T-XX)        :       1.000000

SPECIES HALF LIFE (YEARS) :  3.300E+01 OR DECAY CONSTANT (1/SECS) :  6.656E-10

ROCK DENSITY (GRM/CM**3) :  2.404E+00BULK DENSITY/POROSITY :  2.164E+01

***LINEAR SORBTION*** DISTRIBUTION CONSTANT (KD) :  1.000E+01

***SIP USED***

***CONFINED AQUIFER***

                    EXECUTION PARAMETERS

          NITP    (NO. OF ITERATION PARAMETERS) :    10
          TOL     (CONVERGENCE CRITERIA - ADIP) :     0.0100
          ITMAX   (MAX.NO.OF ITERATIONS - ADIP) :   100
          CELDIS  (MAX CELL DISTANCE PER MOVE
                     OF PARTICLES - M.O.C.)     :     0.200
          NPMAX   (MAX. NO. OF PARTICLES)       :  3200
          NPTPND  (NO. PARTICLES PER NODE)      :       5

                    PROGRAM OPTIONS

          NPNT    (TIME STEP INTERVAL FOR
                   COMPLETE PRINTOUT)          :     2
          NPNTMV  (MOVE INTERVAL FOR CHEM.
                   CONCENTRATION PRINTOUT)     :    10
          NPNTVL  (PRINT OPTION-VELOCITY
                   0=NO; 1=FIRST TIME STEP;
                   2=ALL TIME STEPS)           :     1
          NPNTD   (PRINT OPTION-DISP.COEF.
                   0=NO; 1=FIRST TIME STEP,
                   2=ALL TIME STEPS)           :     0
          NUMOBS  (NO. OF OBSERVATION WELLS

                   FOR HYDROGRAPH PRINTOUT)    :     2
          NREC    (NO. OF PUMPING WELLS)       :     2
          NCODES  (FOR NODE IDENT.)            :     1
          NPNCHV  (PUNCH VELOCITIES)           :     0
          NPDELC  (PRINT OPT.-CONC. CHANGE)    :     0


TIME INTERVALS (IN SECONDS)
    0.13000E+08 0.13000E+08 0.13000E+08 0.13000E+08 0.13000E+08 0.13000E+08 0.13000E+08 0.13000E+08 0.13000E+08 0.13000E+08
    0.13000E+08 0.13000E+08 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00
    0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00
    0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00
    0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00
    0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00
    0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00
    0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00
    0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00
    0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00
    0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00

          LOCATION OF OBSERVATION WELLS

                NO.      X      Y

                 1       4      2
                 2       6      2

          LOCATION  OF  PUMPING  WELLS

          X    Y    RATE(IN CFS)    CONC.

          3    2    -.750E-02      500.00
         17    2    0.750E-02        0.00

          AREA OF ONE CELL :    9.0000E+02

          X-Y SPACING:
              30.000
              30.000
```

```
AQUIFER THICKNESS (FT)
    0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
    0.0 50.0 50.0 50.0 50.0 50.0 50.0 50.0 50.0 50.0 50.0 50.0 50.0 50.0 50.0 50.0 50.0 50.0 50.0  0.0
    0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0


WATER TABLE
    0.    0.    0.    0.    0.    0.    0.    0.    0.    0.    0.    0.    0.    0.    0.    0.    0.    0.    0.    0.
    0.   14.    0.    0.    0.    0.    0.    0.    0.    0.    0.    0.    0.    0.    0.    0.    0.    0.   10.    0.
    0.    0.    0.    0.    0.    0.    0.    0.    0.    0.    0.    0.    0.    0.    0.    0.    0.    0.    0.    0.


TRANSMISSIVITY MAP (FT*FT/SEC)
  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00
  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00
  0.00E+00  3.00E-02  3.00E-02  3.00E-02  3.00E-02  3.00E-02  3.00E-02  3.00E-02  3.00E-02  3.00E-02
  3.00E-02  3.00E-02  3.00E-02  3.00E-02  3.00E-02  3.00E-02  3.00E-02  3.00E-02  3.00E-02  0.00E+00
  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00
  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00


PERMEABILTY MAP (FT/SEC)
  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00
  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00
  0.00E+00  6.00E-04  6.00E-04  6.00E-04  6.00E-04  6.00E-04  6.00E-04  6.00E-04  6.00E-04  6.00E-04
  6.00E-04  6.00E-04  6.00E-04  6.00E-04  6.00E-04  6.00E-04  6.00E-04  6.00E-04  6.00E-04  0.00E+00
  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00
  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00


        NO. OF FINITE-DIFFERENCE CELLS IN AQUIFER =    18

        AREA OF AQUIFER IN MODEL  =  1.62000E+04 SQ. FT.


        NZCRIT   (MAX. NO. OF CELLS THAT CAN BE VOID OF
                   PARTICLES;  IF EXCEEDED, PARTICLES ARE REGENERATED)   =    0


DIFFUSE RECHARGE AND DISCHARGE (FT/SEC)
  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00
  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00
  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00
  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00
  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00
  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00


NODE IDENTIFICATION MAP

    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
    0    1    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    1    0
    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
   NO. OF NODE IDENT. CODES SPECIFIED =  1

       THE FOLLOWING ASSIGNMENTS HAVE BEEN MADE:
   CODE NO.      LEAKANCE      SOURCE CONC.      RECHARGE

      1         3.000E-01      0.000E+00


VERTICAL PERMEABILITY/THICKNESS (FT/(FT*SEC))
  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00
  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00
  0.00E+00  3.00E-01  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00
  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  3.00E-01  0.00E+00
  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00
  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00
```

```
HEAD DISTRIBUTION - ROW        0
NUMBER OF TIME STEPS :
      TIME(SECONDS) :  0.00000E+00
      TIME(DAYS)    :  0.00000E+00
      TIME(YEARS)   :  0.00000E+00

  0.0000000   0.0000000   0.0000000   0.0000000   0.0000000   0.0000000   0.0000000   0.0000000   0.0000000   0.0000000

  0.0000000   0.0000000   0.0000000   0.0000000   0.0000000   0.0000000   0.0000000   0.0000000   0.0000000   0.0000000

  0.0000000  14.0000000   0.0000000   0.0000000   0.0000000   0.0000000   0.0000000   0.0000000   0.0000000   0.0000000

  0.0000000   0.0000000   0.0000000   0.0000000   0.0000000   0.0000000   0.0000000   0.0000000  10.0000000   0.0000000

  0.0000000   0.0000000   0.0000000   0.0000000   0.0000000   0.0000000   0.0000000   0.0000000   0.0000000   0.0000000

  0.0000000   0.0000000   0.0000000   0.0000000   0.0000000   0.0000000   0.0000000   0.0000000   0.0000000   0.0000000



ITERATION PARAMETERS
   9.938E-01 9.938E-01 9.780E-01 9.780E-01 9.215E-01 9.215E-01 7.198E-01 7.198E-01 0.000E+00 0.000E+00
   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00



CONCENTRATION

NUMBER OF TIME STEPS :         0
        TIME(SECONDS) :  0.00000E+00
   CHEM.TIME(SECONDS) :  0.00000E+00
   CHEM.TIME(DAYS)    :  0.00000E+00
        TIME(YEARS)   :  0.00000E+00
   CHEM.TIME(YEARS)   :  0.00000E+00
  NO. MOVES COMPLETED :        0

     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000

     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000

     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000

     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000

     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000

     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000


CONCENTRATION

NUMBER OF TIME STEPS :         0

     0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
     0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
     0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0



  N :      2
  NUMBER OF ITERATIONS :       1



HEAD DISTRIBUTION - ROW        2
NUMBER OF TIME STEPS :
      TIME(SECONDS) :  2.60000E+07
      TIME(DAYS)    :  3.00926E+02
      TIME(YEARS)   :  8.23890E-01

  0.0000000   0.0000000   0.0000000   0.0000000   0.0000000   0.0000000   0.0000000   0.0000000   0.0000000   0.0000000

  0.0000000   0.0000000   0.0000000   0.0000000   0.0000000   0.0000000   0.0000000   0.0000000   0.0000000   0.0000000

  0.0000000  13.9999967  13.9705853  13.6911740  13.4117626  13.1323512  12.8529398  12.5735284  12.2941171  12.0147057

 11.7352943  11.4558829  11.1764715  10.8970602  10.6176488  10.3382374  10.0588260  10.0294146  10.0000033   0.0000000

  0.0000000   0.0000000   0.0000000   0.0000000   0.0000000   0.0000000   0.0000000   0.0000000   0.0000000   0.0000000

  0.0000000   0.0000000   0.0000000   0.0000000   0.0000000   0.0000000   0.0000000   0.0000000   0.0000000   0.0000000
```

```
HEAD DISTRIBUTION - ROW
NUMBER OF TIME STEPS :       2
       TIME(SECONDS) :  2.60000E+07
       TIME(DAYS)    :  3.00926E+02
       TIME(YEARS)   :  8.23890E-01

   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0

   0  14  14  14  13  13  13  13  12  12  12  11  11  11  11  10  10  10  10   0

   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0


DRAWDOWN
      0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
      0    0  -13  -13  -12  -12  -12  -12  -11  -11  -11  -10  -10  -10  -10   -9   -9   -9    0    0
      0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
  CUMULATIVE MASS BALANCE -- (IN FT**3)

   RECHARGE                      :  0.00000E+00
   INJECTION                     : -1.95000E+05
   PUMPAGE                       :  1.95000E+05
   CUMULATIVE  NET  PUMPAGE      :  0.00000E+00
   WATER RELEASE FROM STORAGE    : -8.56124E+01
   LEAKAGE INTO AQUIFER          : -2.29881E+04
   LEAKAGE OUT OF AQUIFER        :  2.29005E+04
   CUMULATIVE  NET  LEAKAGE      : -8.56094E+01

       MASS BALANCE RESIDUAL     :  0.00000E+00
       ERROR  (AS PERCENT)       :  0.00000E+00

  RATE MASS BALANCE -- (IN C.F.S.)

   RECHARGE                      :  0.00000E+00
   LEAKAGE INTO AQUIFER          :  8.82341E-04
   LEAKAGE OUT OF AQUIFER        : -8.82341E-04
   NET LEAKAGE     (QNET)        :  0.00000E+00
   INJECTION                     : -7.50000E-03
   PUMPAGE                       :  7.50000E-03
   NET WITHDRAWAL    (TPUM)      :  0.00000E+00


CONCENTRATION

NUMBER OF TIME STEPS :       2
       DELTA T       :  1.30000E+07
       TIME(SECONDS) :  2.60000E+07
  CHEM.TIME(SECONDS) :  2.59998E+07
  CHEM.TIME(DAYS)    :  3.00923E+02
       TIME(YEARS)   :  8.23890E-01
  CHEM.TIME(YEARS)   :  8.23884E-01
 NO. MOVES COMPLETED :      22

   0.0000    0.0000    0.0000    0.0000    0.0000    0.0000    0.0000    0.0000    0.0000    0.0000

   0.0000    0.0000    0.0000    0.0000    0.0000    0.0000    0.0000    0.0000    0.0000    0.0000

   0.0000    2.8077   69.0890   31.0170    9.0285    1.8241    0.2818    0.0351    0.0037    0.0003

   0.0000    0.0000    0.0000    0.0000    0.0000    0.0000    0.0000    0.0000    0.0000    0.0000

   0.0000    0.0000    0.0000    0.0000    0.0000    0.0000    0.0000    0.0000    0.0000    0.0000

   0.0000    0.0000    0.0000    0.0000    0.0000    0.0000    0.0000    0.0000    0.0000    0.0000


CONCENTRATION

NUMBER OF TIME STEPS :      2

   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0

   0   3  69  31   9   2   0   0   0   0   0   0   0   0   0   0   0   0   0   0

   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
CHEMICAL MASS BALANCE

        MASS IN BOUNDARIES       :  0.00000E+00
        MASS OUT BOUNDARIES      : -3.89376E-15
        MASS PUMPED IN           :  9.74998E+07
        MASS PUMPED OUT          : -3.48514E-08
        INFLOW MINUS OUTFLOW     :  9.74998E+07
        INITIAL MASS STORED      :  0.00000E+00
        PRESENT MASS STORED      :  5.13437E+05
        CHANGE MASS STORED       :  5.13437E+05
        DECAY OF SOLUTE MASS     : -4.03858E+03
        SORBTION STORAGE (S)     :  1.11085E+08
        SORBTION DECAY (S)       : -8.73778E+05
      COMPARE RESIDUAL WITH NET FLUX AND MASS ACCUMULATION.
       MASS BALANCE RESIDUAL     : -1.49787E+07
       ERROR  (AS PERCENT)       : -1.53608E+01
 N :    10
 NUMBER OF ITERATIONS :      1


HEAD DISTRIBUTION - ROW
NUMBER OF TIME STEPS :      10
       TIME(SECONDS) :   1.26230E+08
       TIME(DAYS)    :   1.46100E+03
       TIME(YEARS)   :   4.00000E+00

  0.0000000   0.0000000   0.0000000   0.0000000   0.0000000   0.0000000   0.0000000   0.0000000   0.0000000   0.0000000

  0.0000000   0.0000000   0.0000000   0.0000000   0.0000000   0.0000000   0.0000000   0.0000000   0.0000000   0.0000000

  0.0000000  13.9999967  13.9705854  13.6911740  13.4117626  13.1323512  12.8529398  12.5735285  12.2941171  12.0147057

 11.7352943  11.4558828  11.1764715  10.8970602  10.6176488  10.3382374  10.0588260  10.0294146  10.0000033   0.0000000

  0.0000000   0.0000000   0.0000000   0.0000000   0.0000000   0.0000000   0.0000000   0.0000000   0.0000000   0.0000000

  0.0000000   0.0000000   0.0000000   0.0000000   0.0000000   0.0000000   0.0000000   0.0000000   0.0000000   0.0000000


HEAD DISTRIBUTION - ROW
NUMBER OF TIME STEPS :      10
       TIME(SECONDS) :   1.26230E+08
       TIME(DAYS)    :   1.46100E+03
       TIME(YEARS)   :   4.00000E+00

  0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0

  0  14  14  14  13  13  13  13  12  12  12  11  11  11  11  10  10  10  10   0

  0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0


 DRAWDOWN
      0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0
      0     0   -13   -13   -12   -12   -12   -12   -11   -11   -11   -10   -10   -10   -10    -9    -9    -9     0     0
      0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0

  CUMULATIVE MASS BALANCE -- (IN FT**3)

   RECHARGE                       :  0.00000E+00
   INJECTION                      : -9.46727E+05
   PUMPAGE                        :  9.46727E+05
   CUMULATIVE  NET  PUMPAGE       :  0.00000E+00
   WATER RELEASE FROM STORAGE     : -8.56124E+01
   LEAKAGE INTO AQUIFER           : -1.11423E+05
   LEAKAGE OUT OF AQUIFER         :  1.11338E+05
   CUMULATIVE  NET  LEAKAGE       : -8.55625E+01

       MASS BALANCE RESIDUAL      :  0.00000E+00
       ERROR  (AS PERCENT)        :  0.00000E+00

  RATE MASS BALANCE -- (IN C.F.S.)

   RECHARGE                       :  0.00000E+00
   LEAKAGE INTO AQUIFER           :  8.82341E-04
   LEAKAGE OUT OF AQUIFER         : -8.82341E-04
   NET LEAKAGE     (QNET)         :  0.00000E+00
   INJECTION                      : -7.50000E-03
   PUMPAGE                        :  7.50000E-03
   NET WITHDRAWAL    (TPUM)       :  0.00000E+00


  CONCENTRATION

  NUMBER OF TIME STEPS :      10
         DELTA T       :   9.23040E+05
         TIME(SECONDS) :   1.26230E+08
    CHEM.TIME(SECONDS) :   1.26230E+08
    CHEM.TIME(DAYS)    :   1.46100E+03
         TIME(YEARS)   :   4.00000E+00
    CHEM.TIME(YEARS)   :   4.00000E+00
   NO. MOVES COMPLETED :      16

      0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000

      0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000

      0.0000    34.1466   171.5019   119.3772    89.5955    39.2258    21.1663    10.4521     4.5699     1.9014

      0.7118     0.2464     0.0791     0.0236     0.0086     0.0017     0.0005     0.0000     0.0000     0.0000

      0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000

      0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000
```

```
CONCENTRATION

NUMBER OF TIME STEPS :     10

    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0

    0   34  172  119   70   39   21   10    5    2    1    0    0    0    0    0    0    0    0    0

    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
CHEMICAL MASS BALANCE

       MASS IN BOUNDARIES      :  0.00000E+00
       MASS OUT BOUNCARIES     : -3.48473E-03
       MASS PUMPED IN          :  4.73343E+08
       MASS PUMPED OUT         : -4.42167E+01
       INFLOW MINUS OUTF.OW    :  4.73343E+08
       INITIAL MASS STORED     :  0.00000E+00
       PRESENT MASS STORED     :  2.12887E+06
       CHANGE MASS STORED      :  2.12897E+06
       DECAY OF SOLUTE MASS    : -8.37876E+04
       SORBTION STORAGE (S)    :  4.80461E+06
       SORBTION DECAY (S)      : -2.02928E+07
     COMPARE RESIDUAL WITH NET FLUX AND MASS ACCUMULATION.
       MASS BALANCE RESIDUAL   : -8.83429E+06
       ERROR  (AS PERCENT)     : -2.03537E+00


TEST PROBLEM 3 FOR TRANSIENT SIMULATION WITH SIP OPTION


     TIME VERSUS HEAD AND CONCENTRATION AT SELECTED OBSERVATION POINTS
              PUMPING PERIOD NO.    1



                TRANSIENT  SOLUTION



                    OBS.WELL NO.     X    Y                N     HEAD (FT)    CONC.(MG/L)    TIME (YEARS)
                          1          4    2


                                                           0        0.0           0.0           0.000
                                                           1       13.7           6.2           0.412
                                                           2       13.7          31.0           0.824
                                                           3       13.7          54.1           1.236
                                                           4       13.7          67.0           1.648
                                                           5       13.7          78.1           2.060
                                                           6       13.7          81.1           2.472
                                                           7       13.7          91.9           2.884
                                                           8       13.7         111.1           3.296
                                                           9       13.7         116.9           3.708
                                                          10       13.7         119.4           4.000
                    OBS.WELL NO.     X    Y                N     HEAD (FT)    CONC.(MG/L)    TIME (YEARS)
                          2          6    2


                                                           0        0.0           0.0           0.000
                                                           1       13.1           0.1           0.412
                                                           2       13.1           1.6           0.824
                                                           3       13.1           4.1           1.236
                                                           4       13.1           7.4           1.648
                                                           5       13.1          12.9           2.060
                                                           6       13.1          17.3           2.472
                                                           7       13.1          21.9           2.884
                                                           8       13.1          33.9           3.296
                                                           9       13.1          36.4           3.708
                                                          10       13.1          39.2           4.000
```